Dr Smith

UNITED STATES NAVY

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DEPARTMENT OF THE NAVY
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The Navy has long recognized the importance of pest control in and adjacent to its shore establishments. A program of preventive or corrective measures is required to eliminate, or at least minimize, the insect and animal pests that transmit infectious diseases to military and civilian personnel, destroy or contaminate food supplies and water, or damage equipment and materials, and even structures, at naval activities. Morale may be substantially lowered by such common nuisance pests as mosquitoes and bedbugs.

In this publication are presented for the first time this Bureau's operational techniques and criteria in the field of pest control. They are considered applicable to the entire Naval Shore Establishment.

These policies and procedures are intended for the guidance of Civil Engineer Corps officers and civilian personnel who provide the technical information for planning pest-control programs and facilities. This publication should be a valuable on-the-job guide for entomologists attached to District Public Works Offices to aid them in planning and implementing pest-control programs in cooperation with the Bureau of Medicine and Surgery and other agencies, including architectural-engineering contractors.

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Chief, Bureau of Yards and Docks

FOREWORD

This is the first publication on pest control to be issued by this Bureau. It establishes important criteria and operational procedures to be used by naval personnel concerned with preventive and corrective measures necessary to protect naval shore activities from pests.

Pest-control programs based on these criteria must be integrated closely with fire protection, safety engineering, refuse disposal, and sanitation at activities, particularly if the design of such facilities takes into consideration the eradication or control of pests.

Part A presents the general authority under which this Bureau is delegated responsibilities for pest-control operations, a list of definitions of pertinent terms, and a list of the types of pests. It also delineates the responsibilities of this Bureau in carrying out pest-control operations of the entire Department of the Navy.

Part B deals with the kinds, general description, and characteristics of insects and the methods and equipment used for their control and/or eradication. These insects include mosquitoes, flies, bedbugs, fleas, lice, mites, ticks, spiders, miscellaneous arthropods, cockroaches, ants, termites, stored-product insects, insects that attack grassed areas, and those that damage trees and shrubs.

Part C describes the kinds of rodent and other pest animals, including rats, mice, ground squirrels, prairie dogs, pocket gophers, and moles. Types of rodenticides and equipment, and precautions in their use in protecting Navy property from these pests are also described.

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ACKNOWLEDGMENTS

Figure	*Source*
1-5, 8, 9, 11-16, 20, 21, 23, 24, 29, 32, 40, 63, 64, 75, 76, 86-91	Department of the Army Technical Manual TM5-632, "Insect and Rodent Control"
6, 7, 10	Manual of Naval Hygiene and Sanitation, NAVMED P-126, Vol. I
17a, 17b, 18, 22, 26-28, 30, 31, 33-39, 41-55, 62, 65, 68-70, 74	U.S. Department of Agriculture
60, 66	Minnesota Agricultural Experiment Station
61, 67, 71, 73	Illinois Natural History Survey
72	University of Minnesota Laboratory

PART A. INTRODUCTION

Section 1. GENERAL

A1.01 PURPOSE AND SCOPE

1. PURPOSE. This publication has been prepared by the Bureau of Yards and Docks as a technical and operational guide for naval personnel responsible for pest-control practices in relation to the entire Naval Establishment. Although the criteria presented herein are not intended to limit or restrict initiative in planning and developing further practices consistent with the mission of an activity, wide deviation from established practices should have Bureau approval.

2. SCOPE. Pest-control practices contained herein apply to two general subject groups: (a) the wide field of insect pests, and (b) rodents and other pest animals that are most frequently encountered at the various naval activities.

A1.02 GENERAL AUTHORITY

Under the authority of Navy Regulations, the responsibilities of the Bureau of Yards and Docks for public works at all naval shore activities extend to pest-control facilities and measures. This Bureau has technical responsibility for the development of basic designs for structures and other appurtenances related to pest control, and for the establishment of standards and criteria therefor.

Under the same authority this Bureau is responsible for correlating the interests of the Bureau of Medicine and Surgery and certain other bureaus and government agencies concerned with phases of pest-control measures at naval shore activities.

A1.03 DEFINITIONS

1. PESTS. Pests are considered herein to include all those biological agents, except marine borers, that attack and destroy or contaminate naval property, or that establish a hazard to the health and/or welfare of personnel.

2. PEST CONTROL. Pest control consists of the means or methods used to guard against the depredations of pests, and the corrective measures used in connection therewith.

3. VECTORS. Disease vectors are any organisms, usually insects and/or rodents, that carry and transmit pathogenic microorganisms.

4. PESTICIDES. Pesticides are organic, nonorganic, and synthetic chemicals that are combined with adjuvants, diluents, solvents, and spreaders disseminated for the purpose of killing or controlling insects, rodents, decay-fungi, noxious weeds, and related organisms.

5. ENTOMOLOGIST. An entomologist is the qualified technical consultant for the programming and administering of a pest-control program. Specially trained engineers and biologists may be used in certain phases of pest-control activities.

6. PEST-CONTROL PERSONNEL. Pest-control personnel are those specifically trained and qualified as to adequacy of knowledge pertaining to the safe and efficient application of insecticides, rodenticides, and other toxic chemicals for effective pest control.

A1.04 TYPES OF PESTS

Pests are classified according to their habits and habitat into the following categories: (a) general (nuisance) pests, such as ants, roaches, fleas, bedbugs, and silverfish; (b) disease vectors, such as mosquitoes, flies, fleas, ticks, mites, and rodents; (c) stored-product pests, such as weevils, beetles, moths, and rodents; (d) wood-destroying organisms, including termites and wood-boring beetles; and (e) vegetation pests, such as beetles, moths, fungi, slugs, snails, and noxious weeds.

Section 2. RESPONSIBILITIES

A2.01 GENERAL

1. BUREAU COOPERATION. Responsibility for pest control is divided among the various bureaus and offices of the Naval Establishment by mutual agreement as to their cognizant interests. Close cooperation among all bureaus and offices is an established and essential policy in coordinating a continuous pest-control program.

2. FISCAL. The management-control bureau at a naval shore activity is responsible for budgeting pest-control operations, including service contracts when they are deemed necessary. The funds in such cases are allocated to the Bureau of Yards and Docks, as the bureau responsible for the design, construction, and maintenance of preventive and corrective pest-control structures and measures necessary to protect naval shore stations from pests.

3. CONTROL METHODS. Methods of pest control include: (a) selection of a site free of breeding places for pests, or a site that facilitates their eradication or control; (b) construction of mechanical barriers between structures and pest populations, such as termites, rats, flies, and mosquitoes; (c) sanitary practices to eliminate conditions conducive to the development of general nuisance pests; (d) the use of pesticides; (e) proper storage techniques to prevent pest infestation.

A2.02 BUREAU OF YARDS AND DOCKS

1. GENERAL. This Bureau is responsible for the planning, design, development, procurement, alteration, cost estimates, and inspection of pest-control facilities and appurtenances. It is also responsible for research and development of methods for the control of pests through preventive or eradication measures, and for preparing pest-control guides and establishing standards and procedures. All new developments and operational procedures of a perilous or highly technical nature must be cleared with this Bureau before being adopted. This Bureau is further responsible for contracts, construction, housing, public quarters, chemical warfare equipment, and maintenance of structures, roads, grounds, and utilities with respect to preventive and corrective measures for pest control, utilizing funds made available by the management-control bureaus.

2. FIELD RESPONSIBILITIES. The Chief of the Bureau has delegated certain specific phases of his authority to permanently established authorized field representatives of the Bureau. These authorized field representatives are distinct from those individuals who have a special task to perform as a temporary assignment, and are as follows: Directors, Overseas Divisions, Bureau of Yards and Docks; District Public Works Officers; Officers-in-Charge of Construction; and Commanding Officers of Construction Battalions.

3. DIRECTOR, OVERSEAS DIVISION. The director of an Overseas Division is responsible to, and acts for, the Chief of the Bureau of Yards and Docks in all matters under the cognizance of this Bureau pertaining to construction, maintenance, and operation of all shore stations and activities within his assigned area. Upon request, he will furnish engineering service, planning, administration of real estate matters, and assistance in the procurement and shipment of material and personnel from the Zone of the Interior for the Naval Construction Forces under Fleet, Force, Type, and Base Commands. On projects assigned to the cognizance of the Director, he will designate the Officer-in-Charge of Construction of architectural-engineering and construction contracts after prior approval by the Chief of the Bureau of Yards and Docks, and the Officer-in-Charge of Construction will report to the Director rather than to the Chief of the Bureau.

4. DISTRICT PUBLIC WORKS OFFICER. The District Public Works Officer is responsible to the Chief of the Bureau of Yards and Docks for planning, directing, and carrying out, in accordance with Bureau policies and directives, this Bureau's technical program of design, construction, alteration, and inspection of public works, including pest control, at shore activities within the boundaries of his Naval District.

5. PUBLIC WORKS OFFICER. The Public Works Officer is responsible to the Commanding Officer or the Officer-in-Charge of a naval activity for assuring maximum performance of pest-control facilities within the boundaries of his activity. When authorized by the Bureau of Yards and Docks, he may award and execute short-form contracts for both new construction and for special

phases of pest control. When delegated authority by the District Public Works Officer, he may act as the Resident Officer-in-Charge of Construction for such projects constructed under long-form contracts or CPFF contracts.

6. OFFICER-IN-CHARGE OF CONSTRUCTION. The Officer-in-Charge of Construction is designated by the Chief of the Bureau of Yards and Docks to administer the construction by contract of public works or public utility projects, including pest-control facilities classified as public works. He is responsible for planning, directing, and carrying out, within his area of responsibility, the Bureau's technical program of design, construction, alteration, repair, upkeep, and inspection of public works and public utilities of the Shore Establishment when accomplished by contract.

7. BIOLOGICAL WARFARE. This Bureau is responsible for the development, evaluation, procurement, and distribution of materials and appliances for defense against biological warfare, including insects and rodents that are potential carriers of biological organisms suitable for dissemination by enemy attack.

8. STANDARDS AND SAFEGUARDS. This Bureau is responsible for the promulgation of information relating to safeguards against all forms of pests and hazards to Navy property and personnel in the use of insecticides and fumigants, and the standardization of an economic program to establish these aims.

9. MAINTENANCE OF RECORDS. This Bureau is responsible for maintaining comprehensive records of information reported by the management bureaus on the costs, efficiency, and effectiveness of pest-control methods, materials, and equipment.

A2.03 OTHER BUREAUS AND AGENCIES

The cognizant interests of other Navy bureaus in pest control, as they affect the performance and technical responsibilities of the Bureau of Yards and Docks, are presented in the following paragraphs.

1. BUREAU OF MEDICINE AND SURGERY. The Bureau of Medicine and Surgery initiates recommendations for the control of disease-bearing insects, rodents, and other vermin that may endanger the health and morale of naval personnel, as set forth in paragraphs 22–26 of the Manual of the Medical Department. It also recommends to the Bureau of Yards and Docks, and other cognizant bureaus, suitable chemical formulas, equipment, application techniques, dosages, safety precautions, and other applicable measures. The Medical Officer at a shore activity supervises vector-control operations within specified areas.

2. BUREAU OF SUPPLIES AND ACCOUNTS. Standardization, procurement, and cataloging of pesticides, and their stocking and issuing, is assigned to the Bureau of Supplies and Accounts.

3. BUREAU OF SHIPS. Research, development, and the preparation of specifications for insecticides, rodenticides, and other control agents and dispersal devices, and their laboratory testing, is accomplished by the Bureau of Ships in collaboration with other bureaus.

4. BUREAU OF AERONAUTICS. The development of equipment for aerial dispersal of insecticides, disinsectization of aircraft, and the provision of aircraft for insecticide dispersal, is assigned to the Bureau of Aeronautics.

5. OTHER DEPARTMENTS OF GOVERNMENT. The United States Army, United States Air Force, United States Public Health Service, United States Department of Agriculture, United States Department of the Interior, state, county, and community agencies collaborate with the Bureau of Yards and Docks in the exchange of information and joint participation in field tests and major programs of pest control.

PART B. INSECTS

Section 1. MOSQUITOES

B1.01 MOSQUITOES AS CARRIERS OF DISEASE

1. GENERAL. While mosquitoes are well known for their annoying characteristics, their greatest importance is as carriers of malaria, dengue, yellow fever, filariasis, and encephalitis. Three groups of mosquitoes are of particular medical concern, *Anopheles*, *Aedes*, and *Culex* (Figure 1).

2. MALARIA. Malaria is transmitted from person to person only by mosquitoes of the genus *Anopheles*. The disease is general throughout tropical and subtropical regions of the world. In the United States, it is most prevalent in the southeastern states, although within the last several years its incidence there has been reduced by vigorous control measures.

3. DENGUE. This is an acute infectious disease with a negligible mortality rate occurring in many tropical and subtropical regions. It is of military importance because it may incapacitate large numbers of men at critical periods. Epidemics of dengue have occurred in the Gulf States region of this country. Dengue is carried by mosquitoes chiefly of the genus *Aedes*, which have previously bitten a dengue patient.

4. YELLOW FEVER. This disease occurs now only in Central America, South America, and Africa. Mosquitoes of the genus *Aedes* capable of transmitting yellow fever, however, are distributed generally in tropical and subtropical regions, so that the disease is liable to break out in any area in which a fever case is introduced.

5. FILARIASIS. This is a tropical and subtropical disease transmitted by many mosquito genera, including *Culex*, *Aedes*, and *Anopheles*, which have wide distribution in the United States and other countries.

6. ENCEPHALITIS. Diseases of this type occur in the northern United States, Japan, and other countries and are transmitted by mosquitoes.

B1.02 DEVELOPMENT OF MOSQUITOES

1. GENERAL. The adult female mosquito lays her eggs on the surface of water or on ground liable to flooding. Breeding may be in places such as swamp water, temporary puddles, open cisterns and water tanks, and discarded, water-filled tin cans. Some mosquitoes breed in brackish water. The eggs float on the water and hatch, and the resulting larvae (wrigglers) feed on organic matter in the water, some species at the surface and others at the bottom. The full grown larvae change to nonfeeding pupae (which tumble through the water when disturbed), and soon become adult mosquitoes. Distances that mosquitoes can fly from their breeding grounds vary, according to species, from 500 yards to 10 miles or more. Winds may carry them much farther.

2. CONDITIONS FAVORABLE FOR DEVELOPMENT. To develop, mosquito larvae generally require quiet water containing adequate larval food such as particles of decaying vegetable matter. Anopheline mosquitoes frequently breed in a sunlit pond, swamp, or stream of water containing vegetation or debris, which furnishes both a source of food and a protection from the wind (Figure 2). Yellow fever mosquitoes (*Aedes aegypti*) commonly breed in artificial water containers in and around human habitations. Common breeding places of *Culex* mosquitoes are ground pools, irrigation ditches, and rain barrels.

B1.03 MOSQUITO CONTROL

1. GENERAL. Methods of mosquito control are directed against adult mosquitoes and the breeding places of mosquito larvae. Control of adult mosquitoes involves barriers (screens) and insecticides. Control of larvae requires elimination of favorable water conditions or treatment of the water to prevent their development. Control methods are either temporary or permanent.

2. TEMPORARY CONTROL METHODS. Until permanent measures can be put into effect, temporary control must be attempted wherever mosquitoes may be a problem. (Permanent meas-

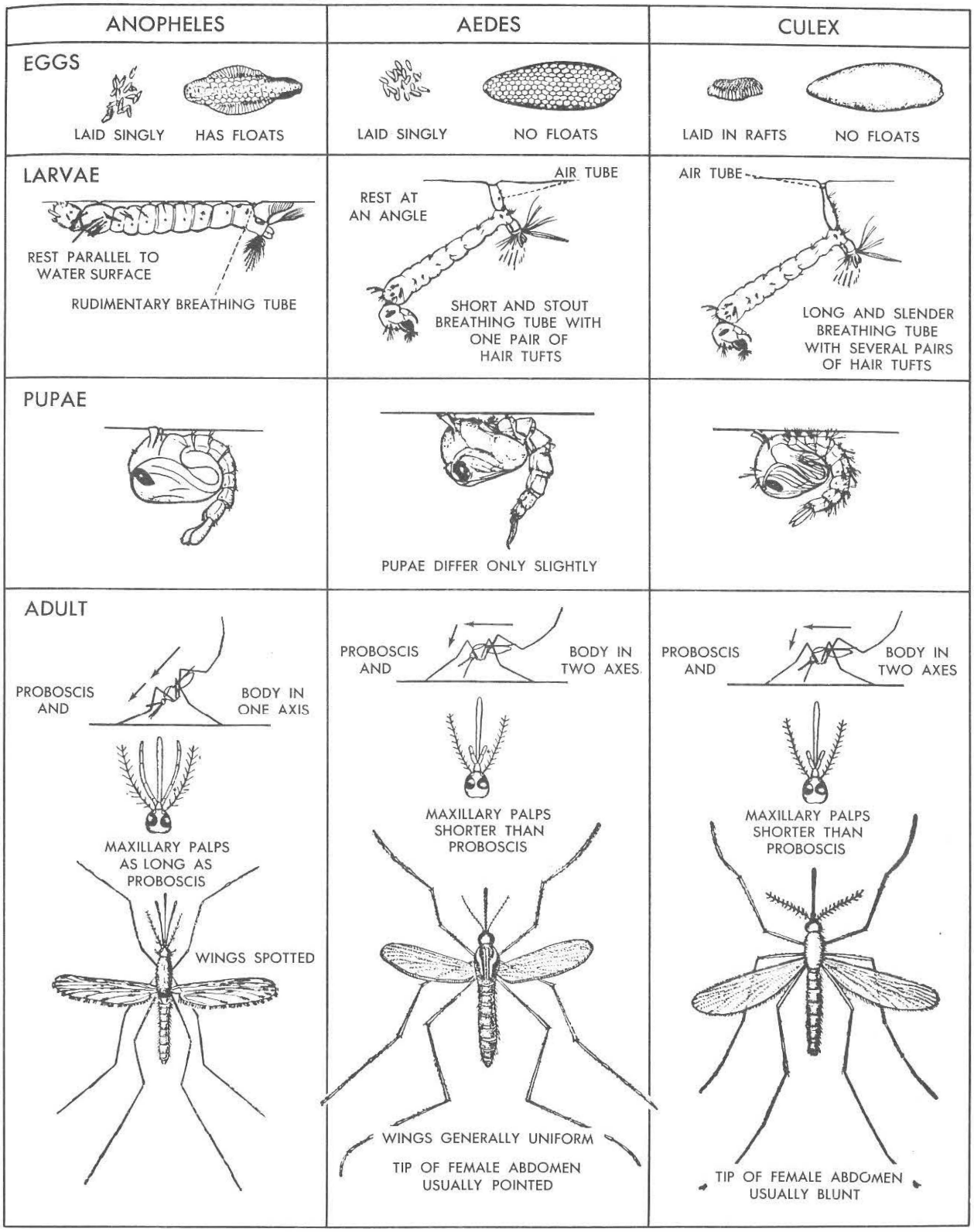


FIGURE 1

Principal Characteristics for Identifying the Three Mosquito Genera of Medical Importance

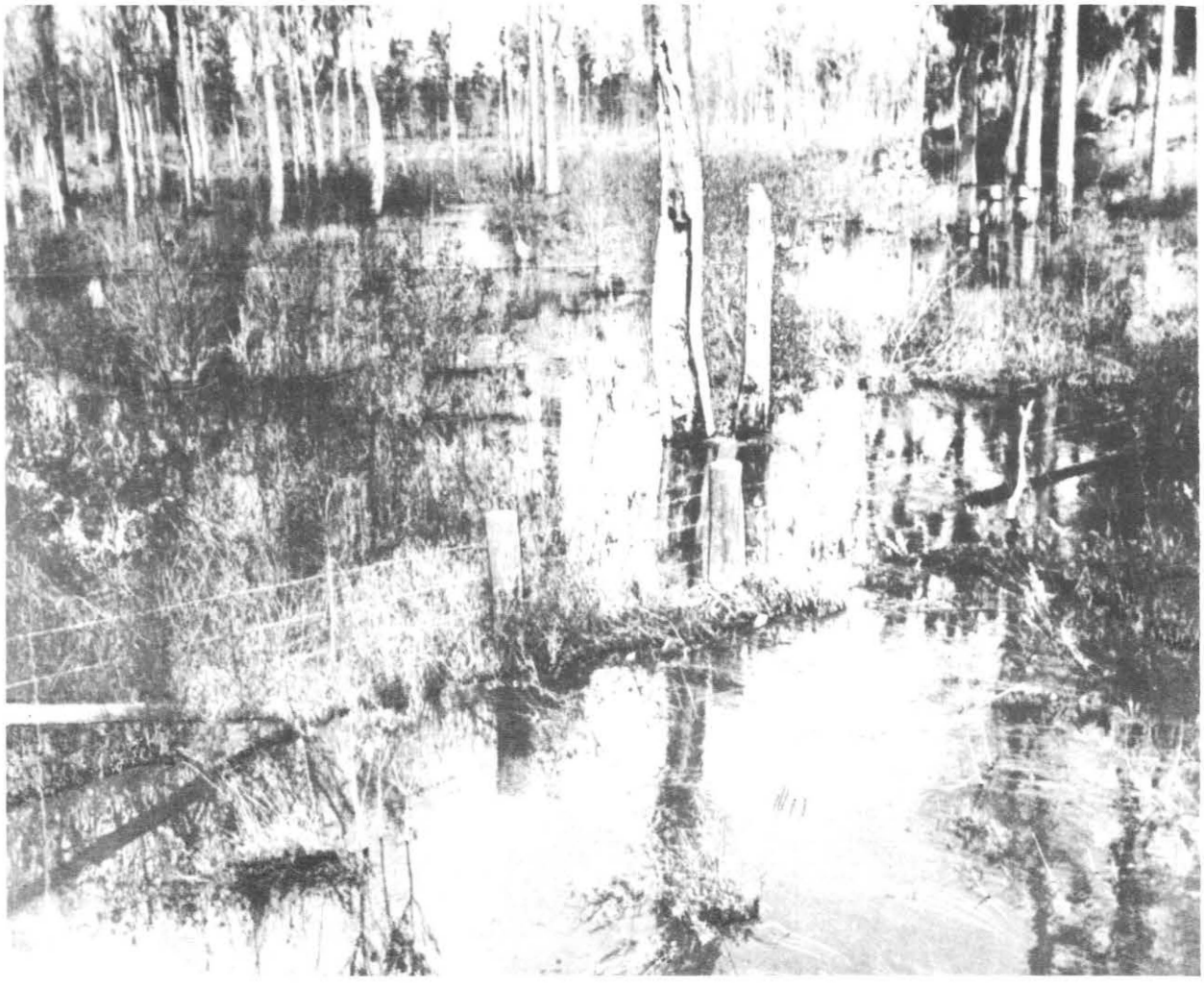


FIGURE 2

Typical Mosquito-Breeding Area

ures may not be practical at temporary sites because of prohibitive costs.) Temporary measures against larvae include treatment of infested water areas with insecticides. Measures against adult mosquitoes include the application of sprays both indoors and out.

3. PERMANENT CONTROL METHODS. Permanent measures against mosquito larvae are designed to eliminate or control the water in which breeding takes place. Ditching, pumping, filling, and similar measures requiring considerable time, labor, and equipment are involved, but the initial high cost must be weighed against the cost of temporary measures. No permanent program is recommended until careful surveys have been made by experienced entomological personnel. Adequate building screens control adult mosquitoes indoors.

B1.04 MANAGEMENT OF SURFACE WATERS

1. IMPROVEMENT OF STREAM FLOW. Improving the flow of shallow, sluggish streams containing plant growth reduces mosquito breeding and is usually less expensive than other permanent measures. Stream conditions may be improved by:

(1) Surveying to ensure that enough grade is available for the improvement of stream flow.

(2) Removing obstructions to flow, such as vegetation, fallen timber, and sand bars.

(3) Beginning at upper end of stream, straightening and cutting down banks at proper angles; beginning at lower end is feasible if survey is accurate.

(4) Digging or blasting new, straighter

channels across turns (Figure 3) if stream is crooked.

(5) Using excavated dirt as fill at upper ends of old channel, holes, and low spots, and a temporary dam of logs, stumps, and riprap to force stream through new channel and prevent washing-out of fill.

(6) Leaving lower ends of sections of old channel open to complete drainage into new stream course.

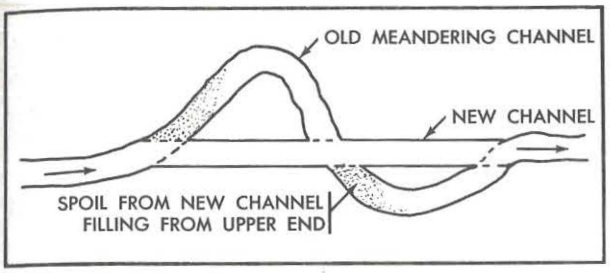


FIGURE 3

Rechanneling Crooked Stream

2. STREAM FLUSHING. Mosquito breeding may also be controlled in a stream by occasional flushing. Build a small dam, with a sluice gate to hold back the water and open the gate periodically, or install an automatic siphon. Alternate drying and flooding will control anopheline mosquitoes in rice fields. (See Figures 4 and 5.)

3. PONDS AND RESERVOIRS. Maintain shore-line drainage, remove and burn drift, and control the growth of shore-line vegetation. Surface-feeding fish may sometimes be used as a supplementary control of mosquito larvae and are particularly useful in ornamental pools. Killfishes (*Fundulus*), in salt water, and top minnows (*Gambusia, Lebistes, Panchax*), in fresh water, are the most useful kinds. (Removal of marginal

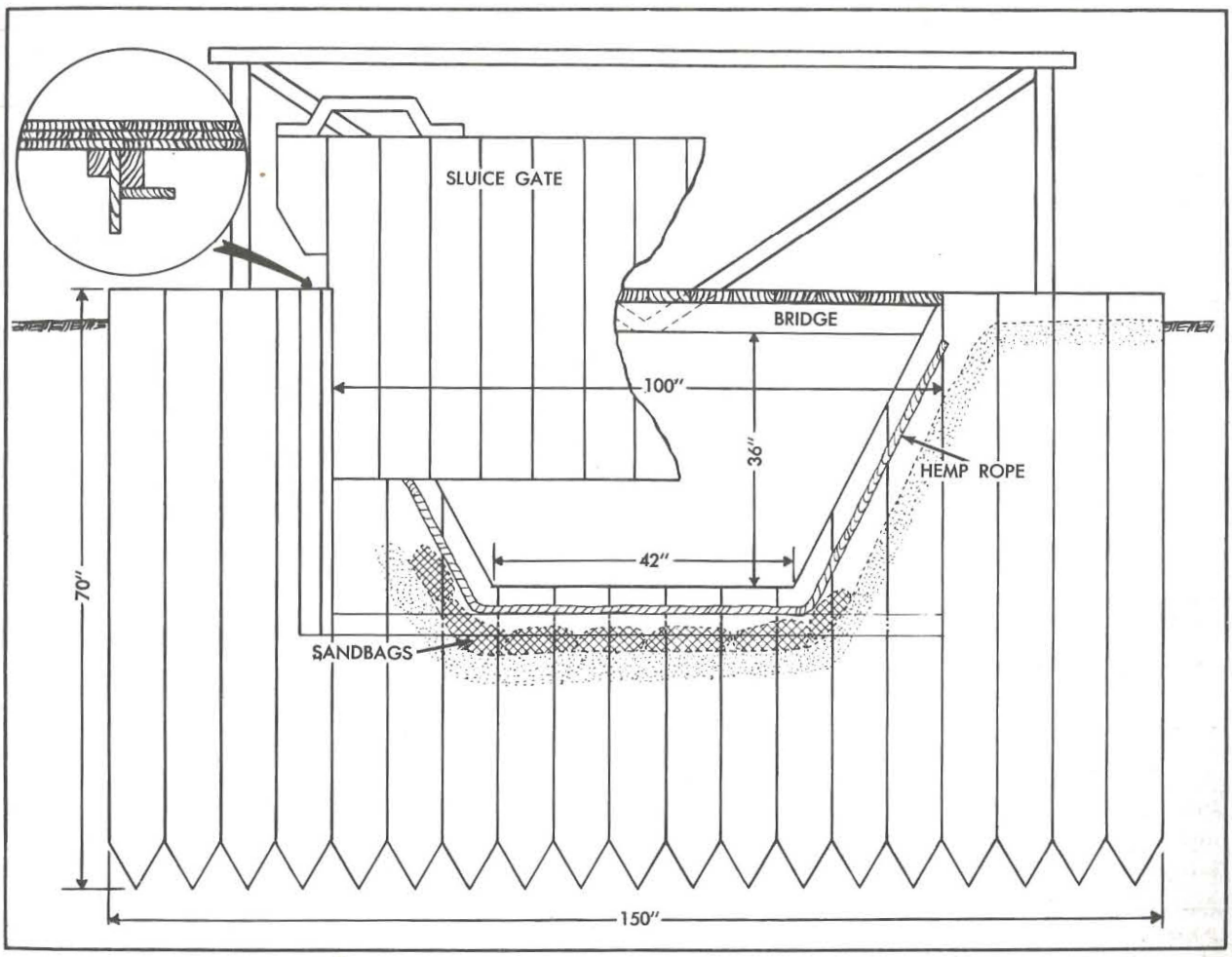


FIGURE 4

Diagram of Sluice Gate

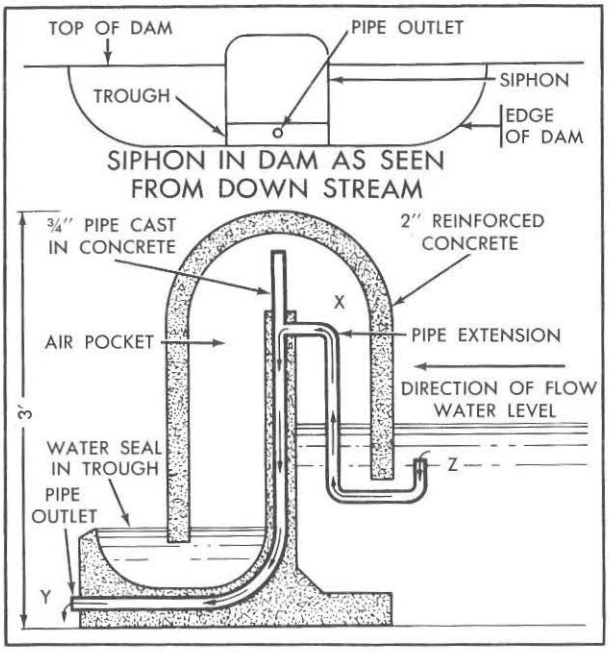


FIGURE 5

Diagram of Automatic Stream Siphon

aquatic plants enables fish to catch mosquito larvae more readily.)

a. Control of Water Level. Control of mosquito breeding in artificial ponds and lakes for water storage depends upon proper reservoir preparation and water-level fluctuation.

(1) Prepare reservoir area to present a clear water surface between maximum and minimum water levels; weeds, stones, and stumps should be removed so as to eliminate protection for mosquito breeding as much as possible.

(2) Drain all depressions between maximum and minimum water levels so water will rise and fall in such places with the water in the main reservoir.

(3) Start filling reservoir in winter after mosquito-breeding season.

(4) Lower water level at intervals of not more than 10 days; mosquito eggs, larvae, and pupae are usually most numerous in protected areas of the water surface near the shore, and are left stranded above the new water level along with protective weeds and other debris. Subsequent drying kills the insects. Water-level management may involve a cyclical fluctuation (drawdown and refill to previous level), seasonal recession, or a combination of the two methods.

b. Flood Waters. Heavy rains and flooded streams may submerge land bordering rivers and ponds, providing mosquito-breeding areas. Ditches may be dug to remove the surface water before mosquito larvae can complete their development, and shallow pools and depressions may be filled and graded. Many such depressions are made during construction work and should be filled by the construction crews. Care must be taken to begin the fill at a point farthest from the outlet to prevent formation of a drainage barrier. Many mosquito-breeding areas may be eliminated and land reclaimed in coordination with the preparation of sanitary fills for waste disposal.

B1.05 COASTAL MARSHES

1. GENERAL. Mosquito breeding in coastal marshes is frequently controlled by altering the salt content (salinity) of the water, or by the use of dikes and tide gates to prevent flooding.

2. SALT CONTENT OF WATER. Some species of mosquito breed only in water containing a certain percentage of salt. Opening channels to permit sea water to enter, or excluding it, may control breeding. Technical advice and assistance of higher headquarters must be obtained for projects of this type.

3. TIDE GATES. Tide gates prevent tidewater from backing into natural-water courses or ditches. A simple gate consists of a heavy, creosoted wooden flap at the end of a culvert, suspended on galvanized, wrought iron pipe (Figure 6). Cast iron gates with frames set in reinforced concrete are more permanent. The gate operates like a simple check valve, and usually does not exceed 36 by 36 inches. Two or more gates may be used side by side. Breakwaters and arrowheads may be installed to prevent blocking of outfalls by sand washed in by the surf.

B1.06 DITCHING AND DRAINING

1. GENERAL. Water requiring drainage may be pond water, storm water, spring water, tidewater, swamps, lagoons, or marshy areas. Ditching for mosquito control must be adequate to remove water so that ground surfaces will dry and water levels in ditches return to normal within about 7 days after a storm. Soil texture, topography, vegetation, maximum rainfall, and high tides in salt marshes should be considered. Ditching plans and operations should be coordinated with road, railway, airfield construction, water supply, and sewage disposal systems.

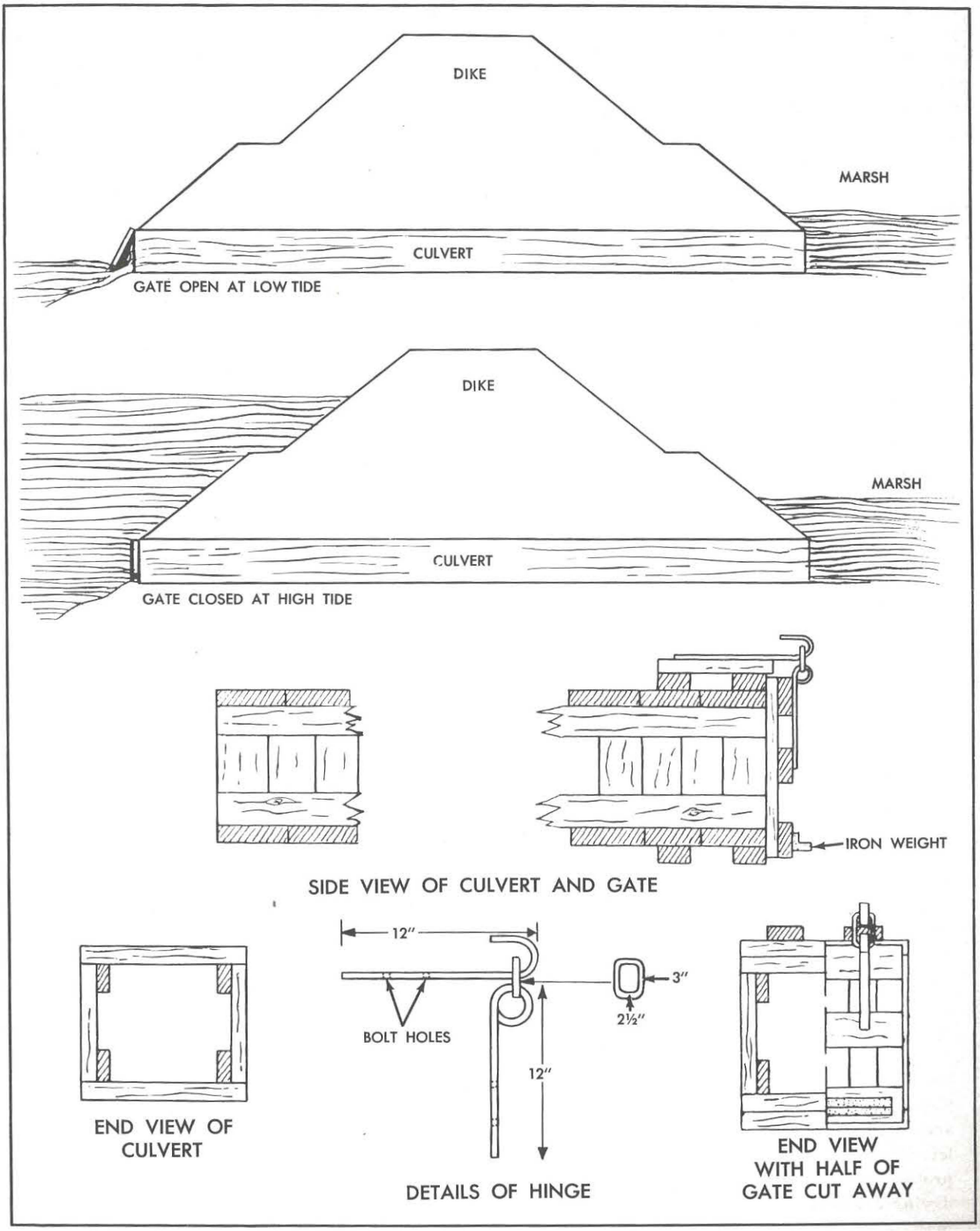


FIGURE 6

Construction of Tide Gate

2. OPEN DITCHES vs. CLOSED DRAINS. Open ditches, unlike underground drains, remove large volumes of water rapidly, have low initial cost, operate where the water table is high, and function well where drainage is temporary. They are, however, subject to erosion and are expensive to maintain. If improperly designed or poorly constructed, they may become mosquito-breeding sites. There are three kinds of ditches:

(1) Main ditches for surface water runoff, usually comprising a primary ditch fed by lateral ditches and conducting the water to a convenient river, lake, or bay.

(2) Diversion ditches to take water from its natural course, as away from a swampy area or away from breeding places, to an area where larvae can be more easily controlled by biological or larvicidal methods.

(3) Seepage or contour ditches to intercept water seeping through the soil from high ground before it reaches a lower swampy area, and to conduct the water to a primary ditch or other outfall.

Swampy areas may be so slightly elevated above their displacement ditches that flow by gravity is impossible. In this case the water may be flushed by tidal action, removed by pumping, or collected for ease in larviciding.

3. PLANNING DITCHES. Because ditch construction is expensive, layouts should be planned with as little footage as possible. A longer, shallower ditch following a natural depression, however, is more economical and efficient than a

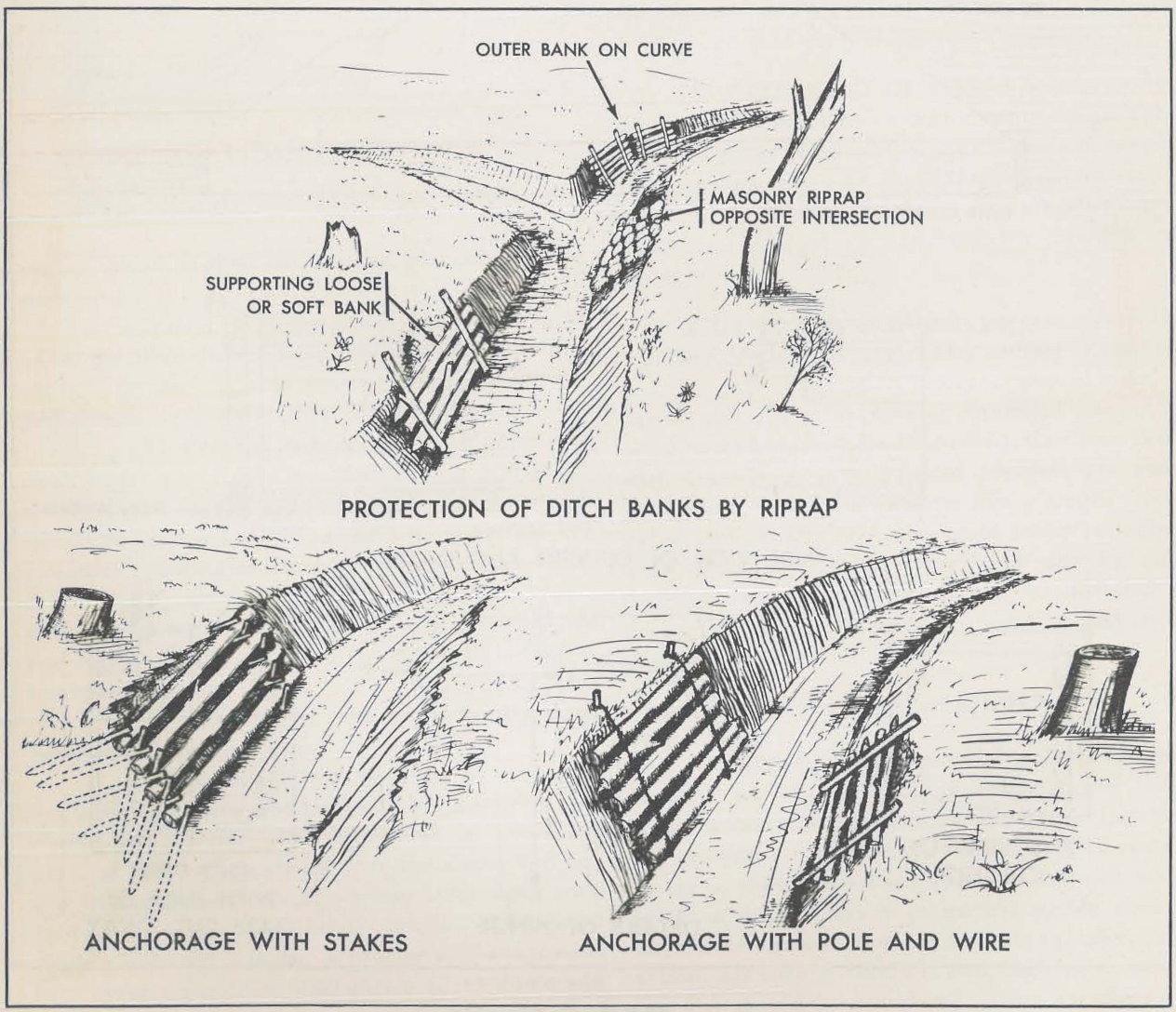


FIGURE 7

Various Types and Placement of Riprap

shorter, deeper ditch through high ground. Ditches with gentle, rather than abrupt, curves are less likely to erode and less difficult to maintain. If a sharp curve can not be avoided, outside banks should be protected with riprap, such as stones or driven stakes and log revetment (Figure 7).

a. Mapping. Sketch maps should be made showing the relative location of the project, including a profile of the outlet ditch showing ground elevation, grade of the proposed ditch, and the cut at each station.

b. Outfall. The outfall should be low enough to provide adequate grade between the lowest point in the drainage area and the point of discharge, and located where water no longer presents a mosquito-breeding hazard.

c. Grade. Establishing a proper grade is essential in the construction of drainage ditches. The gradient in an open ditch ordinarily is as steep as possible to prevent silting without erosion of the bottom and sides. An average water velocity of from 2 to 3 feet a second usually prevents silting yet does not cause erosion except in fine, loose sands. For mosquito control, a grade of about 0.2 percent (a 0.2-foot drop in 100 feet) usually makes the best ditch (Figures 8 and 9). More grade is needed for a small flow than for a large flow of water. Grades in excess of 0.6 percent or less than 0.05 percent are generally unsatisfactory. When there are steep grades, these may be reduced with steps or check dams to reduce velocity. Erosion may be prevented at steps by wood, masonry, or concrete splatter plates (Figure 10).

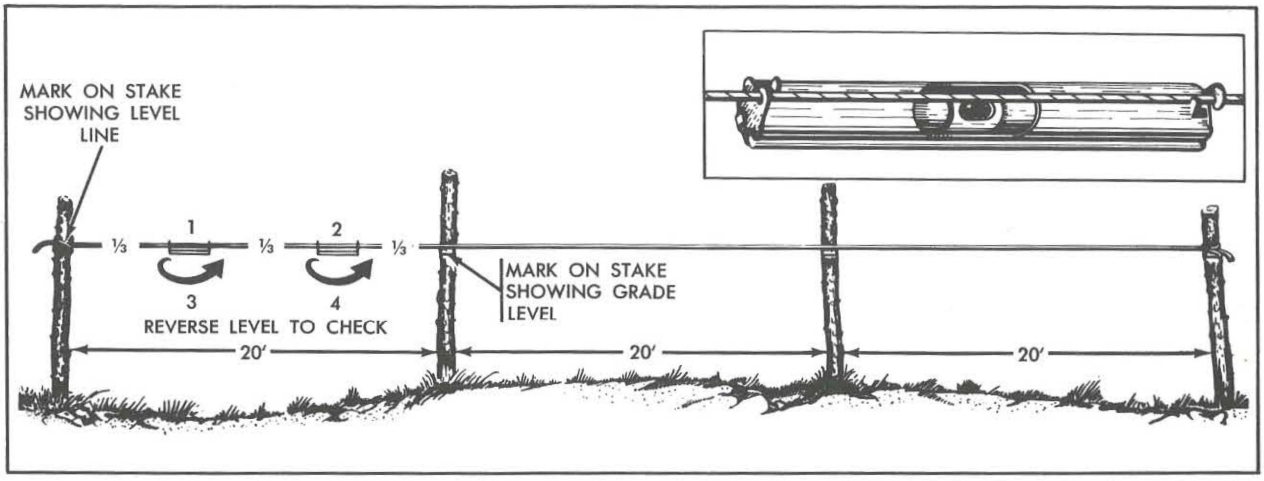


FIGURE 8

Method of Determining Grade With Line Level

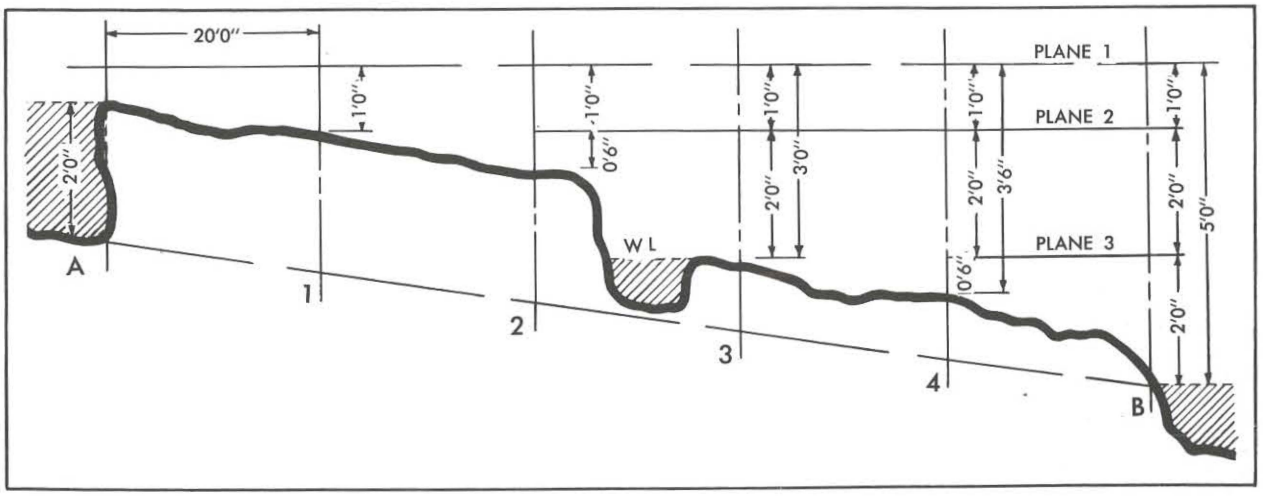


FIGURE 9

Method of Establishing Grade Line To Drain Pools Into Outfall

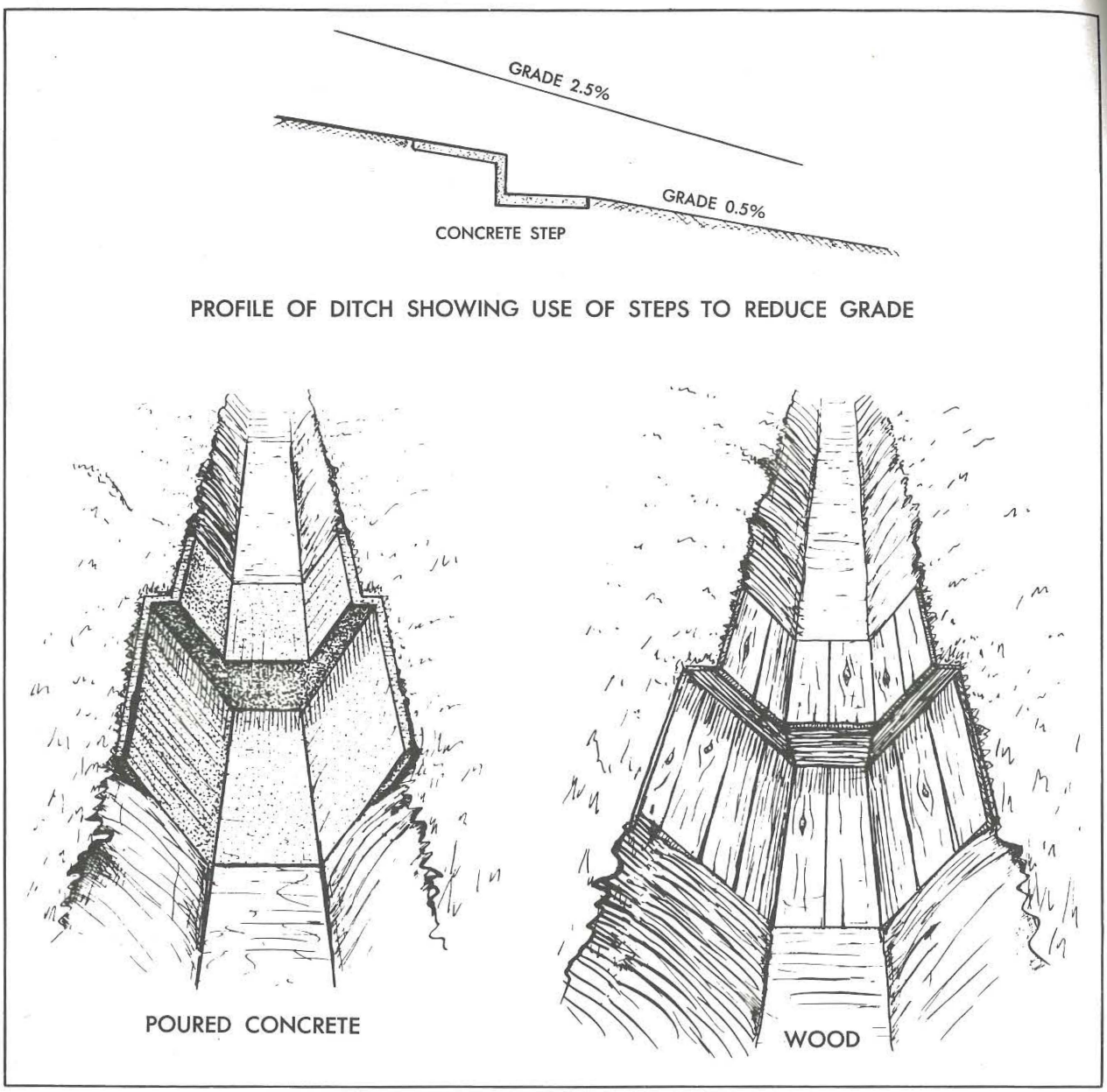


FIGURE 10

Concrete and Wooden Steps To Reduce Grade Without Erosion

d. Ditch Bottom. Velocity of water flow depends upon cross-sectional design of the ditch as well as grade. A V- or U-shaped ditch bottom is recommended over a flat bottom because reduced water volume is concentrated during dry periods and increased velocity reduces silt deposits (Figure 11). Ditches range in width from 12 to 14 inches for draining small ponds to several feet for large areas. Since the flow of water increases from the upper to the lower end, the ditch width in a drainage system should be increased gradually as the ditch proceeds downgrade or as the volume of water is supplemented by contributing channels.

e. Bank Slope. The slope of the ditch bank must depend on the character of the soil. Steep banks tend to cave in, and flat banks require excessive excavation. Usually, the bank slope should vary from ½:1 (½ foot horizontal to 1 foot vertical) in stiff clay to 3:1 in loose, sandy soil (Figure 12). Vertical ditch banks are sometimes used for small ditches cut through thickly matted grass roots.

f. Angle. Ditches should join at an angle of about 30 degrees in the direction of flow to prevent erosion between the ditches because of a narrower angle or erosion at the opposite banks because of a wider angle. Lateral ditches should be brought into a main ditch several inches above the bottom of the latter, with the drop graded over a distance of several feet. Otherwise, pools are likely to form at the mouth of the lateral.

4. EXCAVATING DITCHES. Construction details must be supplied by the supervisor. The work is done by hand labor, power equipment, explosives, or combinations of these.

a. Procedure. Construction of the ditch usually begins at the outlet and proceeds upgrade. To cut the ditch to the planned grade, set a line at a convenient height above the ground, parallel to the desired ditch bottom. This line is usually set about 5 feet above the grade of the ditch and stretched over batter boards nailed across stakes on opposite sides of the proposed ditch. Digging ditches deeper than 5 feet with hand labor is seldom satisfactory. Deeper ditches are dug with machinery, although sides and bottoms may be dressed by hand. Ditches dug by blasting may contain loose material which requires shaping with hand tools after the sides and bottom become packed and stabilized.

Dynamiting is successful chiefly in soft, boggy, or sandy ground where hand or machine digging is difficult, and is also prescribed for ground with many roots and stumps. It is faster than other methods of digging, the cost is frequently less, and spoil (excavated soil) is scattered, creating a saving in labor necessary to dispose of it.

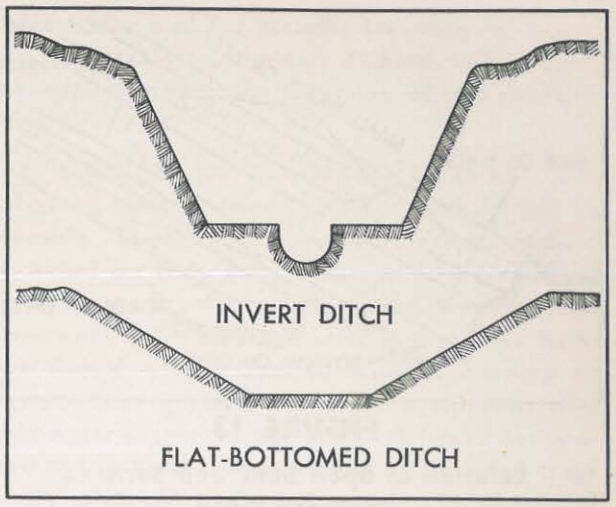


FIGURE 11

Typical Shapes of Ditch Bottoms

Ditching with dynamite or other explosives, however, should not be attempted without expert assistance and a trained crew.

Excavated soil forming a spoil bank along the ditch should be leveled off for some distance, or placed to leave a berm from 3 to 8 feet wide between the ditch and the spoil bank. The berm serves as a path for maintenance crews and prevents the spoil bank from caving in the ditch walls or washing back into the ditch. Breaks must be provided in spoil banks for surface drainage (Figure 13).

b. Ditch Lining. When the ditch bank is unstable, it may require the support of a line of poles securely pegged into the bank at the toe of the

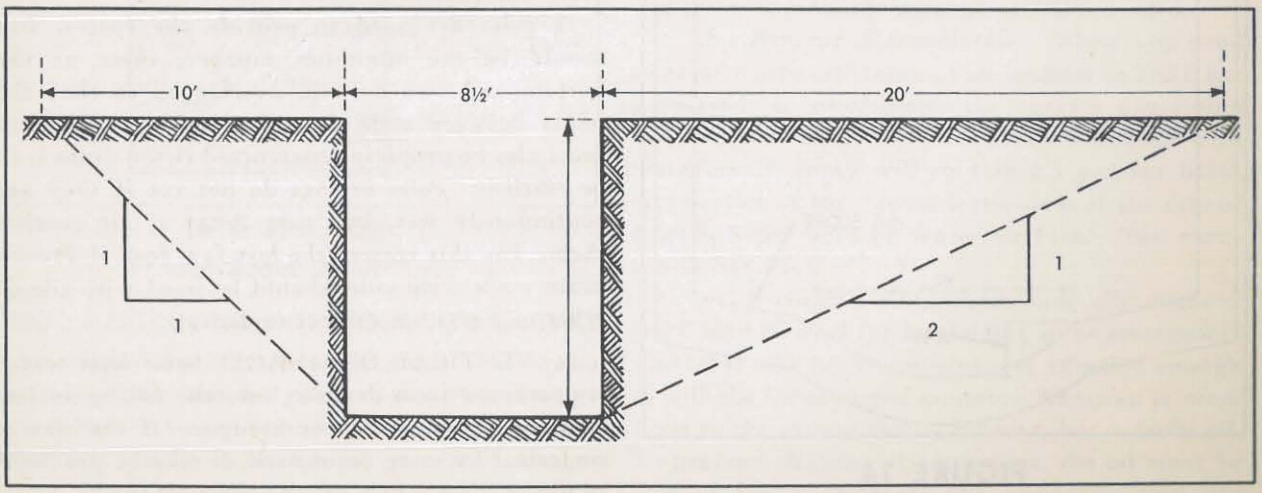


FIGURE 12

Method of Determining Slope of Ditch Bank

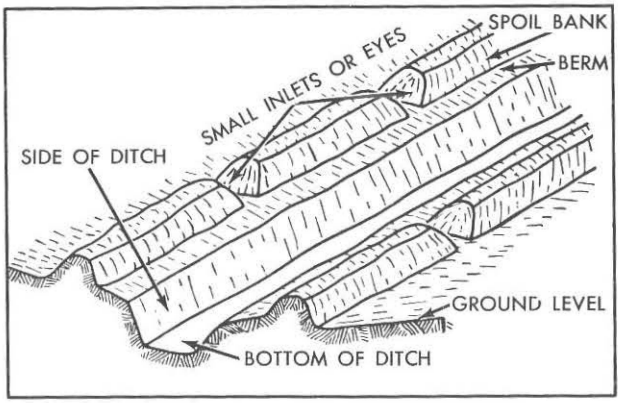


FIGURE 13

Relation of Spoil Bank and Berm to Drainage Ditch

slope. To prevent erosion, open ditches are sometimes lined with concrete, native stone, logs, or other suitable material. This practice is too expensive, however, for any but exceptional conditions, although maintenance costs are lower for lined ditches. Along roadways and other locations where large quantities of water must be drained, but where water flow is not continuous, a shallow grass-lined ditch is often more economical although application of a larvicide may be necessary at times. Narrow half-tile inverts may be laid along the center line to carry off residual water. In such ditches, the grass retards water flow so that considerable water is absorbed directly into the soil.

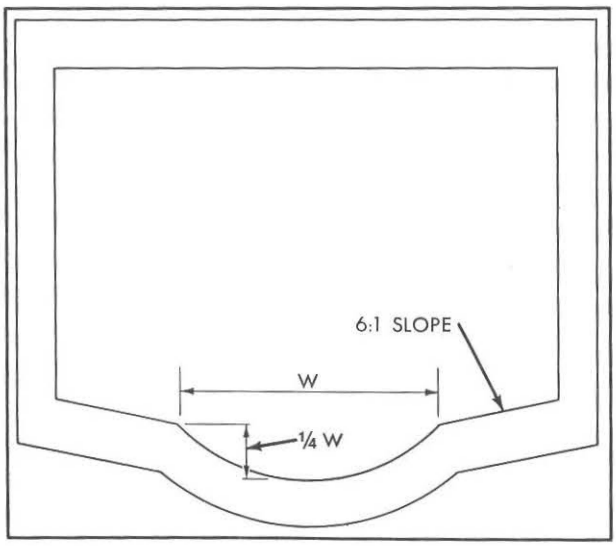


FIGURE 14

Design of Typical Round-Bottom Concrete Culvert

c. Culverts. Culverts should be designed so that water pools in which mosquitoes will breed do not form. The intake end of the culvert must be low enough and of sufficient size to drain all the water from the high side of the roadway or other fill. An apron should be constructed at the outlet of the culvert if the rate of flow or the drop in level is likely to form a pothole (Figure 14).

5. DITCH MAINTENANCE. The efficiency of an open drainage system deteriorates seriously if ditches are not properly maintained. Maintenance should be carried on in those seasons when the work load is lightest.

6. UNDERGROUND DRAINS.

a. General. High initial cost of subsoil drainage prohibits its use in most malaria-control work, but the method is useful if open ditches are undesirable or impossible to maintain. Their chief disadvantage is the formation of inaccessible pools in which mosquitoes can breed. Porous drain tile, crushed or small rock, and poles may be utilized. An open, free-flowing outlet is necessary for underground drains. Competent technical supervision must be given to the construction of a subsoil drainage system.

b. French Drains. French drains are economical and well adapted to drainage for mosquito control (Figures 15a and 15b). Underground drainage is provided by the spaces between rock, coarse gravel, or poles from 4 to 8 inches in diameter. These materials should be surrounded by a porous filter of hay, weeds, leaf mold, or sand to facilitate movement of water into the drainage spaces, and to prevent soil from washing in to block the drain.

If poles are used to provide the spaces, five should be the minimum number, three at the bottom and two on top, overlapped so that the joints between ends do not coincide. The filter must also be properly constructed if the drain is to be efficient. Poles or logs do not rot if they are continuously wet, but soon decay if air reaches them. For this reason, the last few feet of French drain made with poles should be lined with tile or other material not subject to decay.

7. VERTICAL DRAINAGE. Sometimes water is prevented from draining into the soil by an impervious layer of clay or hardpan. If the clay is underlaid by more porous soil, it may be practical to dig or blast a hole or pipe through the hardpan, permitting water at the surface to soak into the subsoil.

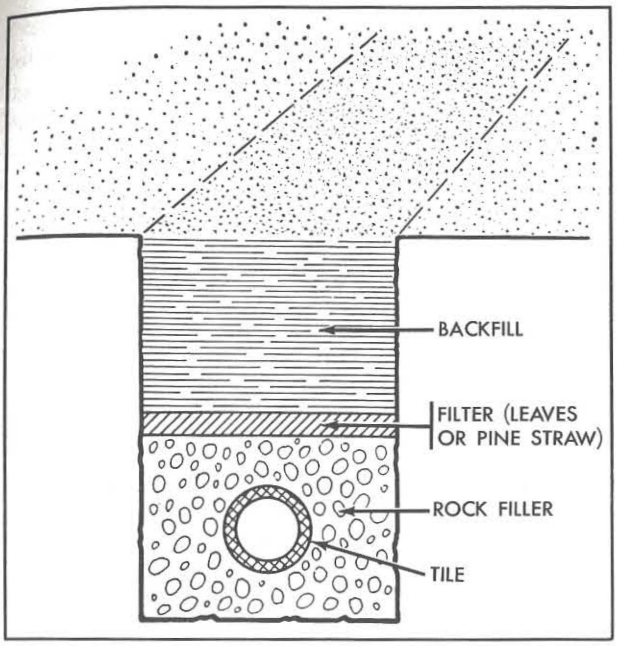


FIGURE 15a

French Drain Using Tile

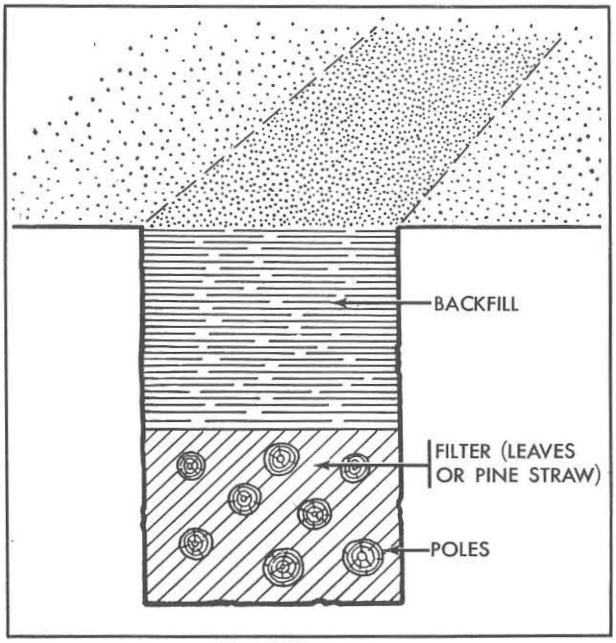


FIGURE 15b

French Drain Using Poles

B1.07 DESTRUCTION OF MOSQUITO LARVAE

1. GENERAL. Temporary methods of mosquito control include the destruction of larvae (wrigglers) by treating water surfaces with chemical larvicides, usually by spraying. (Removal of vegetation aids in the effective use of such chemicals.) Larvicides are relied upon while drainage and other permanent control measures are being developed, and are also used for periodic treatment of water not practicable to eliminate. Chemical larvicides are applied under the direction of the medical officer.

2. SOURCES OF MOSQUITO LARVAE. Not only may streams, ponds, swamps, and ditches be breeding places, but water-filled locations such as discarded tin cans, empty coconut husks, cisterns, water cans, fire barrels, watering troughs, and ornamental pools may also breed mosquitoes. Rubbish should not be dumped without burning or burial. Roof gutters, and other equipment, that hold water require cleaning. Catch basins not constructed to be self-draining and water-filled traps in drains should be flushed periodically or treated with larvicide. Cisterns and rain barrels should be fitted with covers, either solid or screened, to prevent egglaying. Borrow pits should never be dug without provision for proper drainage.

3. CHEMICAL LARVICIDES.

a. DDT. In general, oil solutions of DDT and DDT emulsions are applied at the rate of 0.1 to 0.2 pound of DDT for each acre of water surface. This amount of DDT is contained in from 1 to 2 quarts of 5-percent DDT solution or emulsion. When this small volume can not be applied evenly, 5 to 10 quarts of 1-percent DDT solution or emulsion may be substituted. Treatments at the rate of 0.1 pound of DDT to the acre are usually adequate for from 6 to 9 days' control. Prolonged effectiveness up to 3 or 4 weeks may be obtained with applications of 0.5 to 1.0 pound DDT per acre. Ordinarily, such heavy dosages are wasteful as well as dangerous for fish and wild life. Sewage and mud increase the amount of DDT needed.

b. Benzene Hexachloride. When approved in areas where resistance of mosquitoes to DDT has developed, an emulsifiable concentrate containing BHC may be used. The concentrate is diluted with water so the spray will contain 0.5 percent BHC. Application of the diluted larvicide is at the rate of 3 gallons per acre of water surface. (See paragraph B14.02.)

c. Petroleum Oil. Petroleum oils without DDT may be used for larviciding in an emergency. The oil should be inexpensive, yet effective enough to kill the larvae upon contact. Kerosene is more toxic to the insects than a heavier, less volatile oil. To prevent clogging of equipment, the oil must be free of foreign matter. Oils generally used are diesel oil, fuel oil (No. 2), or kerosene. Use of waste motor oil is not recommended because it is

not very effective, tends to clog the sprayer, requires costly handling, and does not spread evenly on the water surface. The average amount for each application of oil is from 15 to 20 gallons per acre, although some conditions may require up to 35 gallons per acre. More oil is required on water having vegetation and surface debris than on clear water.

B1.08 CONTROL OF ADULT MOSQUITOES INDOORS

1. SCREENING BUILDINGS. Buildings should be constructed without cracks or unnecessary openings. Windows, doors, and ventilating spaces of hospitals, mess halls, and barracks should be screened with noncorrosive, weather-resistant material such as copper, bronze, aluminum, or a plastic.

a. Mesh Size. The wire diameter and size of screen openings are important. Screens with openings no larger than 0.0475 inch in diameter are recommended. Ordinary wire screen must have at least 18 meshes to the inch; heavy copper screen must have 16 to the inch with a wire diameter of 0.015 inch. The openings of regular 16-mesh screen, ordinarily produced from finer wire, are too large. Standard 18-mesh wire screening has a wire diameter of 0.009 to 0.010 inch and meshes of 0.0456 inch. This size of opening excludes both malaria-carrying mosquitoes and the smaller pest species.

b. Screen Construction. Screen doors should open outward and be self-closing. Combination screen and panel doors (Figure 16) are recommended for new construction or for repair of doors. When copper screening is used, the frames must not be painted with a zinc-base paint or fastened with galvanized nails because they set up an electrolytic reaction that splits the screen from the frame. The reaction is avoided by using lead-base paint and nongalvanized nails.

2. USE OF RESIDUAL INSECTICIDES. The use of insecticides to destroy adult mosquitoes that may find their way indoors is under the direction of the medical officer. A 5-percent solution of DDT in kerosene may be applied so as to wet interior wall surfaces thoroughly without running off. A dosage of 1 quart of the solution to 250 square feet is usually effective up to 3 months on average surfaces. Applications are made especially where mosquitoes are likely to rest as on screen doors, window screens, bed nets, ceilings and walls, in corners, behind pictures, and on the undersurfaces of chairs, tables, and beds. DDT emulsion concentrate containing 20 percent DDT may be used rather than 0.5 percent DDT in oil. It is applied after dilution by adding one part to three parts of water. When approved for such use, lindane emulsion may be substituted for DDT sprays. The lindane emulsion concentrate is diluted to make a spray containing 1 percent lindane. One gallon of the diluted insecticide will treat 750 square feet of surface. Residual applications of lindane in living quarters will be limited to spot treatments with the 0.5 percent concentration until more information is available. Both DDT and lindane, applied as described, act to kill the insects when they walk on the deposits of insecticide. The killing action lasts for a considerable period after application.

3. USE OF SPACE SPRAYS. To kill mosquitoes and other flying insects immediately in an enclosed space, fill it with a fine mist or fog-like spray of suitable insecticide as directed by the medical officer. An aerosol dispenser (Navy Stock No. 51-G-120-31) is a convenient means of application.

B1.09 CONTROL OF ADULT MOSQUITOES OUTDOORS

1. GENERAL. Aerosols and finely atomized (fogged) oil-base or emulsion sprays of suitable insecticides are especially useful in killing adult mosquitoes for several hours in areas where personnel are bivouacked, working, or meeting, and where more permanent measures are not feasible or have not yet become entirely effective. Results are most satisfactory when the air is quiet.

2. TREATMENT BY AIRCRAFT. Under certain conditions, as when extensive areas are infested by adult mosquitoes, approval of aircraft for application of insecticides may be obtained in accordance with regulations. Although various types of planes have been equipped for this purpose, area control of adult mosquitoes from the air in the United States is done mainly with large planes spraying 20 percent DDT.

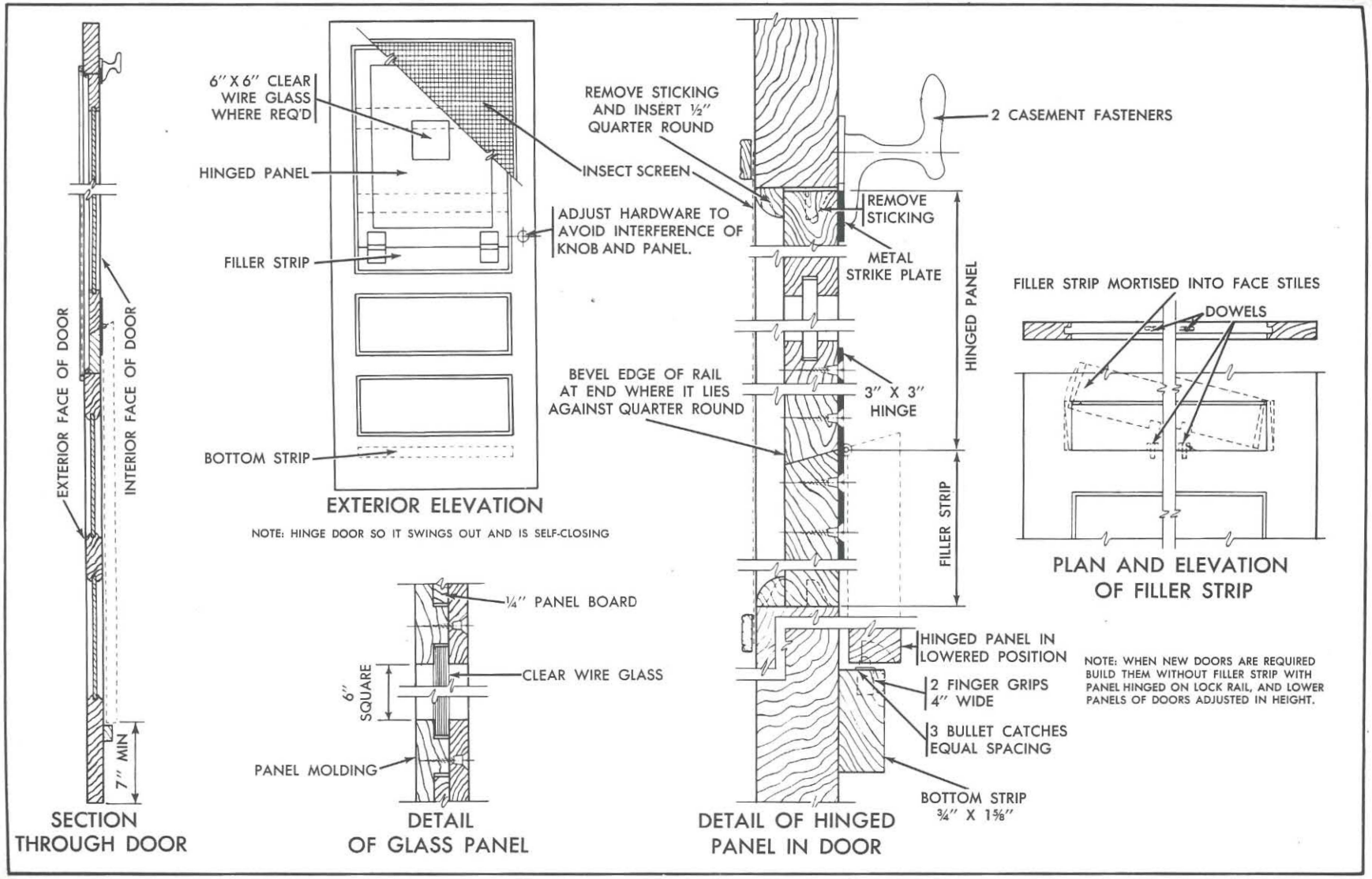


FIGURE 16

Combination Screen and Panel Door

Section 2. FLIES

B2.01 KINDS AND CHARACTERISTICS OF FLIES

1. GENERAL. There are many kinds of flies, but all resemble mosquitoes in several respects: they are two-winged insects, have four stages of development—egg, larva, pupa, and adult—and a number of species are known to carry disease. Many are a source of annoyance to humans and animals.

2. HOUSE FLY. The house fly is the most common fly in many parts of the world (Figure 17a). It annoys man and domestic animals, but can not bite, and carries bacteria and other disease-producing organisms on its feet and in its excrement. Several important diseases are carried by the house fly, including dysentery, diarrhea, cholera, and typhoid fever. House flies feed on decaying waste materials, including human and animal feces, then frequently fly to human food within a short time, spreading disease. They are known to fly from 4 to 8 miles from breeding places in search of food.

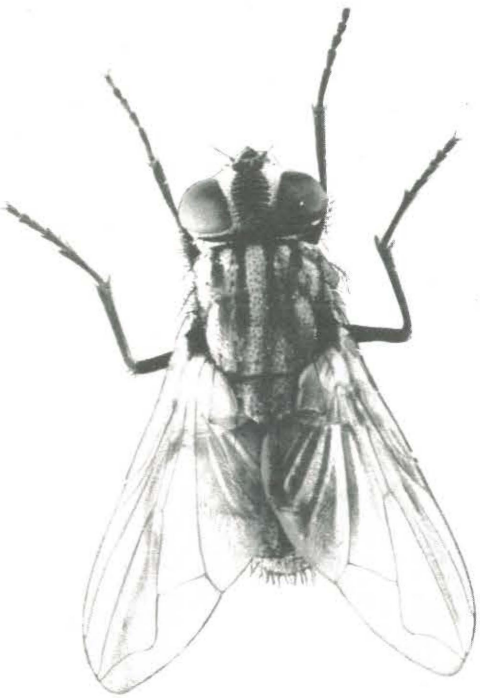


FIGURE 17a

House Fly Adult

This fly breeds in animal and vegetable refuse,

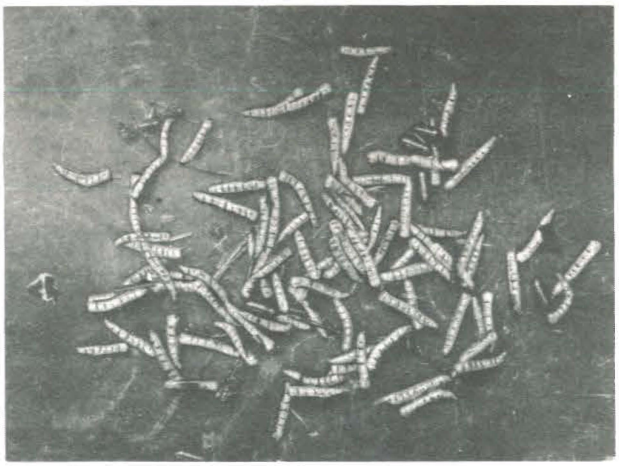


FIGURE 17b

House Fly Larvae (Maggots)

its slender white larvae (maggots) being found in damp organic material. (See Figure 17b.) Under favorable conditions of warmth, it develops from egg to adult in from 8 to 16 days. Each female lays from 200 to 600 eggs, and 10 to 12 generations develop each summer in a climate like that of Washington, D.C.

3. STABLE FLY. The stable fly (dog fly) is found throughout the world. It looks much like the house fly, is a vicious biter of man and animals and, where numerous, can make life almost unendurable (Figure 18). It is believed, however, that it has little to do with spreading disease.

The stable fly normally breeds in wet straw, manure mixed with straw, or any piled and fermenting accumulation of wet vegetation such as exposed cured hay and straw, shore deposits of marine grasses and seaweed along bays, sounds, and inlets, and in rain-moistened litter and strippings resulting from the harvest of peanuts, celery, onions, or other agricultural crops. Aided by wind, adult flies may drift many miles from their breeding place.

4. BLOW FLIES. Various kinds of blow flies, greenbottle flies, and bluebottle flies breed in garbage, decaying meat and fish, animal and human excrement, and filth such as that found around improperly maintained latrines. Adult flies are

FIGURE 18
Stable Fly

potential carriers of disease, and because they often occur in large numbers, are annoying to humans.

5. SAND FLIES (PHLEBOTOMUS). Sand flies are tiny, blood-sucking gnats that transmit a number of subtropical and tropical diseases.

In the United States, sand flies are found in the Atlantic and Gulf coast states, but the only man-biting kind is found in southwestern Texas (information concerning their breeding grounds is very incomplete). They invade buildings to attack man during the evening and night and hide in dark, protected places during the day. Their length ranges from less than 1/16 inch to a little over 1/8 inch. Their flight range is limited to between 100 and 200 yards from their breeding grounds.

6. BLACK FLIES AND PUNKIES. Black flies (buffalo gnats) breed in swiftly flowing streams. Adult flies are small (less than 1/16 to nearly 1/4 inch long), stout and hump-backed in appearance, and have short legs and antennae. Adults have been found more than 4 miles from their breeding grounds. They bite freely in the outdoors during the daytime, and are known to be carriers of human disease parasites in Mexico, Central America, and Africa.

Punkies, often called no-see-ums because of their minute size, are widely distributed over North America, the West Indies, and down the Atlantic coast of South America to Brazil. Because of their size, they can pass through ordinary window screen mesh. Although information on their breeding habits is not complete, some species are known to breed in fresh-water inlets and tidewater pools, and in the decaying humus of densely shaded areas along streams, grassy marshes, and mangrove swamps. Adult punkies have been found 2 and 3 miles from their breeding places. The female inflicts a painful bite, and attacks humans chiefly in the evening and early morning hours. In some tropical regions, they are known to transmit filarial worms to humans.

7. HORSE FLIES AND DEER FLIES. These flies are vicious, blood-sucking insects that attack domestic animals, and common kinds attack and feed freely on humans, but do not enter buildings to bite animals or people. They transmit a number of diseases, including tularemia (from rabbits).

Horse flies and deer flies are robust, with powerful wings, and large, rounded heads. They range in size from about that of the house fly to nearly an inch long, prefer warm, sunny situations, and are especially active on humid days. Their larval development is usually in wet soil, mud, or water, so adult flies are more abundant along the margins of streams, lakes, marshes, and river-bottom land.

8. EYE GNATS. These flies are attracted to wounds, pus, and secretions about the eyes and nose, and transmit pinkeye in various parts of the southern United States, especially southern California. They are blackish flies about 1/16 inch in size, breed in loose, cultivated soil containing organic material, such as human and animal excrement, and swarm in large numbers.

9. MOTH FLIES ("PSYCHODA"). These tiny, dark, hairy flies breed in the slime of trickling filter beds and sometimes in raw sludge at sewage treatment plants. They are a nuisance indoors but do not bite.

10. MIDGES. Various nonbiting, mosquito-like midges and gnats, as well as other insect forms, are often a nuisance because of their numbers, especially when attracted to lights at night, and damage newly painted surfaces by sticking to the wet paint. They usually originate in nearby bodies of water, such as ponds, reservoirs, and slow-running streams.

B2.02 FLY CONTROL

1. HOUSE FLY. It is essential to eliminate all unnecessary sources attracting house flies when

undertaking control measures. Good sanitation and careful policing of breeding grounds are of utmost importance in this work.

a. Disposal of Garbage. Proper disposal of kitchen wastes including garbage and liquids, such as wash water, is highly essential to prevent the attraction of flies to mess halls. (See *Refuse Disposal*, NAVDOCKS TP-Pu-1.)

(1) Garbage must be deposited in garbage containers, with tight-fitting lids, kept outside the mess hall or residence on drained paving or a raised concrete platform. The platform and surrounding ground surface should be sprayed with a 5-percent DDT spray once a week or after every heavy rain in fly season. A rack for garbage containers that has no hidden corners or cracks (Figure 19) is easily built, maintained, and cleaned.

(2) Trash barrels are potential breeding places of house flies that should not be neglected at Navy shore stations. Organic debris is placed in these cans and residues accumulate in the bottom until they support fly maggots. Weekly steam cleaning of all waste cans and other trash collection bins is essential to pest control.

(3) Fly maggots can develop only in moist materials. The practice of spreading decomposing organic matter, such as manure or vegetable refuse, to dry assists in fly control. The egg and larval stages of the house fly require five or more days, and short periods of rain, or irrigation, followed by drying, will stop their development.

(4) An effective method of permanent disposal of garbage and rubbish at camps of considerable size is the sanitary landfill (Figure 20).

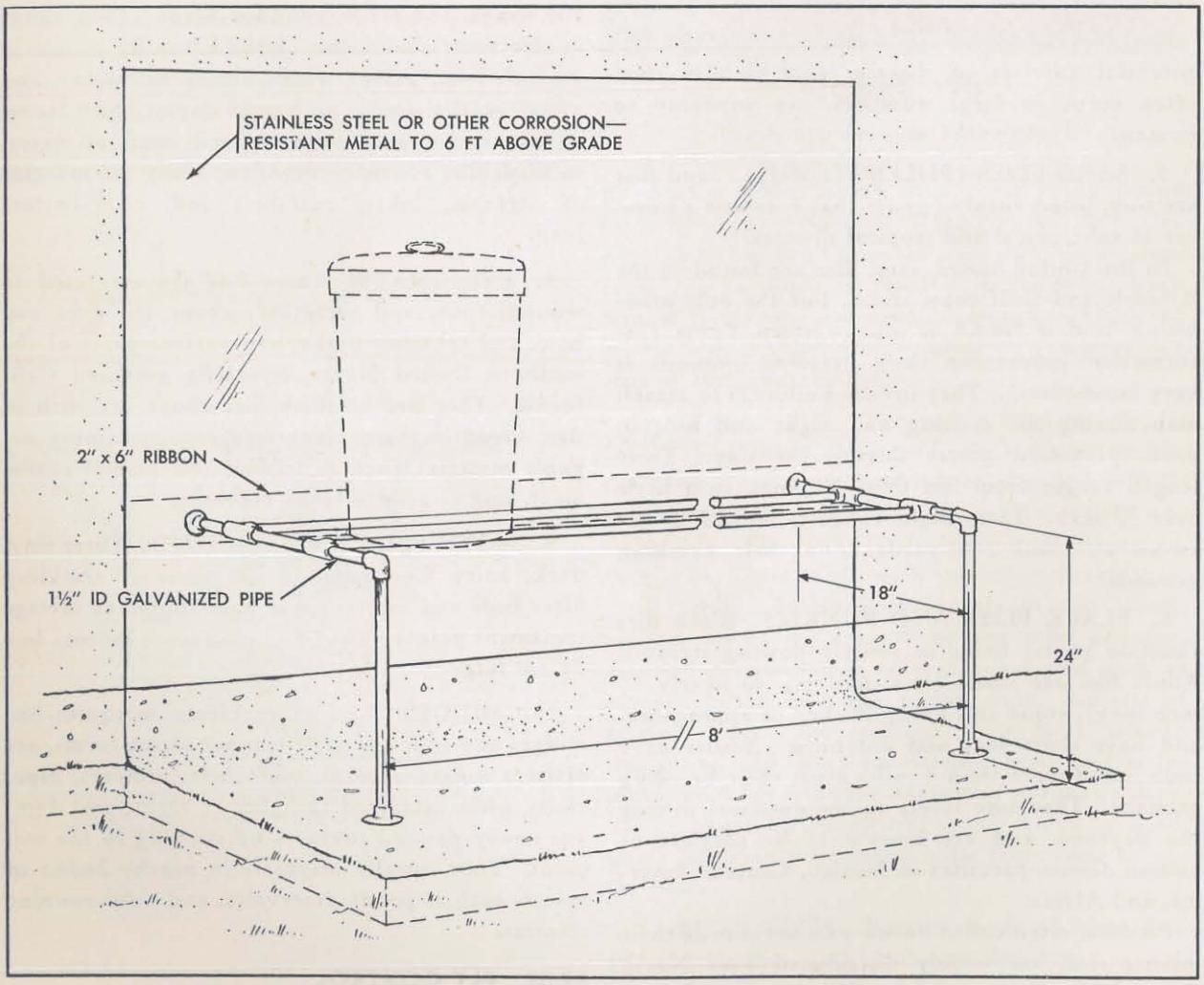


FIGURE 19

Rack for Garbage Containers

Earth, preferably sandy soil, should be available for cover material. (Clay soil should not be used because it is likely to shrink and leave open cracks.) The earth covering must be put on promptly to keep out rats and other vermin, and to prevent the escape of odor or the outbreak of fire. Maintenance of the completed fill involves trimming and filling of cracks and eroded places.

(5) Garbage of smaller activities, as when on the march or in bivouac, may be buried in trenches or pits three or more feet in depth. Each day the accumulation of garbage must be sprayed thoroughly with a suitable insecticide, such as 1 percent chlordane in kerosene (see paragraph 3 of B14.02), 5 percent DDT in kerosene, or latrine oil. When the trench or pit is filled to within 24 inches of the top, the garbage is given a final spraying and then covered with 24 inches of well-packed soil.

(6) Disposal by burning may also be approved, but care must be taken to ensure safe and economical operation. Incineration must be complete to prevent an increase rather than a decrease in fly breeding. Success of incineration depends on the character of the waste, the type of incinerator, the climate, and the quality of opera-

FIGURE 20

Operation of Sanitary Landfill

tion and supervision; for instance, during seasons of heavy rainfall, incineration frequently fails.

(7) For further instructions regarding burning and other methods of refuse disposal see *Refuse Disposal*, NAVDOCKS TP-Pu-1.

b. Treatment of Breeding Places. Outdoor areas likely to be breeding places should be sprayed periodically, paying particular attention to the ground and enclosures around latrines and garbage racks, the inner and outer walls of latrine pits and boxes, and the walls and screens of latrine enclosures. Use a DDT residual spray (5 percent DDT in oil, a 5-percent DDT emulsion, or a 2.5-percent wettable-powder suspension) at the rate of 1 quart per 200–250 square feet.

In localities where flies have developed a resistance to DDT, it may be necessary to substitute a 2-percent chlordane or 0.5-percent benzene hexachloride spray at the rate of 1¼ quarts per 250 square feet. Two ounces of either spray, or one ounce of 10-percent DDT powder sprayed in each latrine-box hole twice a week also helps to prevent breeding.

Control results chiefly from residual action of the spray on newly emerged adult flies and, to some extent, on the maggots. Chlordane and lindane sprays are likely to be more effective than DDT for controlling larvae. Sodium arsenite or paradichlorobenzene may also be used for larvae control in pit latrines when recommended.

c. Screening. Buildings should be screened to exclude flies. Flies often migrate to new areas and develop despite efforts to destroy breeding places. Adult flies should be prevented from contacting food and drink as they may be disease-laden. Precautions observed in the installation and maintenance of fly screens are the same as given for the exclusion of mosquitoes in paragraph 1 of B1.08.

d. Spraying Indoors. Exposed food and utensils in mess halls and galleys should be covered to prevent spray contamination. Personnel doing the spraying should be protected as specified in paragraph B14.03.

Spot treatment by means of heavy applications of residual insecticides to roosting places, such as hanging pictures, light cords, protected corners, and wherever fly specks are seen, will often give better control than spraying of walls. It results in considerable saving of labor and materials. Residual spraying of outside resting places, especially overhanging roofs, helps to prevent flies from entering buildings.

Apply 5-percent DDT spray (either oil solution or diluted emulsion concentrate). A 3-gallon, compressed-air sprayer, equipped with a fan nozzle, is recommended for application of the spray. The nozzle should give a coarse, wet spray and should be held 8 to 15 inches from the surface being treated (Figure 78). Air pressure should not exceed 40 pounds to a square inch. Paint sprayers or other equipment which produce a fine mist are not suitable for making residual deposits of insecticide. The recommended dosage of 1 quart of 5-percent DDT spray to 250 square feet is usually effective up to 3 months on average interior surfaces. The spray should wet the surface thoroughly, but not run off.

If flies have developed resistance to DDT, lindane may be used for residual applications under supervision of trained personnel. Lindane emulsion of 0.5 percent should be sprayed on surfaces at the rate of 1 gallon to 750 square feet. Because of its vapor, chlordane is not approved for interior application.

e. Fly Traps. Fly traps may provide an index to breeding and population but are not considered satisfactory as a control measure.

2. STABLE FLY. Potential breeding places should be dusted with 10-percent DDT powder, sprayed with 5-percent DDT solution in kerosene, 2 percent chlordane in kerosene, or composted and sprayed or dusted. Waste vegetation should not be left exposed in layers thick enough to ferment and decay when wet.

Adult stable flies in bivouac areas may be controlled by spraying tents, shelters, and outside places where the flies congregate. A 5-percent DDT residual insecticide may be used.

3. BLOW FLIES. Locations frequented by adult blow flies should be sprayed with 5-percent DDT residual insecticide, as for the house fly and stable fly. Breeding places should be properly treated or eliminated. Disposal of infested matter is essential.

4. SAND FLIES ("PHLEBOTOMUS"). Sand flies, because of their flight habits, are vulnerable to the action of residual insecticides. On reaching a building the adult flies frequently rest on outer walls, then enter in a series of short, hopping flights between relatively long pauses. Once in a room, however, they may linger on walls again before seeking a blood meal. Application of a residual

spray in the same manner as recommended for house flies and mosquitoes is suitable for control.

Sleeping quarters, rooms occupied after dusk, and door and window exteriors including a foot or two of the wall surrounding these openings, should be treated. It is also recommended that tents be sprayed, including interior surfaces and all openings. Treatment with 5 percent DDT in kerosene or an emulsion will provide almost complete freedom from sand flies for 2 months or longer.

In some cases partial, local area control may be obtained by spraying the usual outdoor shelters of sand flies with DDT, chlordane, or BHC. These include stone-masonry walls, vegetation, trunks of trees, and other resting places within 200 yards of human habitation.

5. BLACK FLIES. Screening against black flies is unnecessary because these insects seldom enter buildings, and insect repellents and repellent-treated clothing are usually enough protection outdoors. Gnatproof veils and clothing are also recommended under certain conditions. Where there are serious outbreaks of black flies, assistance of higher authority should be requested for control recommendations, such as treatment of streams in the area with DDT sprayed from aircraft.

6. PUNKIES. Treatment of screens with a 5-percent DDT solution will kill many of these insects as they attempt to pass through the wire mesh. Further control may be obtained by spraying bed nets with the same solution. Repellents are also valuable in protecting personnel from bites of these insects. Treatment of breeding areas, however, should only be undertaken after requesting assistance from higher authority.

7. HORSE FLIES AND DEER FLIES. Outdoor attacks by these insects may be prevented with mosquito repellents or an oil solution containing 0.1 percent of pyrethrins and 1 percent piperonyl butoxide.

8. EYE GNATS. General sanitation methods, such as the proper disposal of excrement and decaying organic matter, are important factors in eye gnat control.

a. Trapping. Effective traps may be made with half-gallon tin cans. With top covered, cut several 1-inch holes near the bottom in such a way that the resulting flaps of metal can be turned up to shade the openings. Cover the openings with mesh fine enough to keep out blow flies, permitting the entrance of gnats, and attach a screw top, wide-mouth glass jar at right angles over a large opening in the side of the can, near the top. Place a bait of liver and water in the bottom of the trap. The gnats enter through the screens to feed and are then attracted to the well-lighted trap jar at the top (Figure 21).

FIGURE 21

Bait Trap To Capture Eye Gnats

b. Control Indoors. For indoor control, spray DDT on walls, screens, and so on, in the same manner as for sand flies (paragraph 4 of B2.02).

9. MOTH FLIES. Larvae in filter beds at sewage treatment plants may be controlled by flooding. DDT emulsions may be introduced intermittently, at the rate of 1 part to 1,000,000, into the influent of the beds. Cleaning slime from drain and overflow pipes and floor drain traps by thorough brushing, steaming, or alkali cleaners will prevent breeding in these spots. Spraying resting places with DDT will also reduce gnat population.

10. MIDGES. DDT residual sprays applied to resting places around breeding areas will often materially reduce the number of nonbiting midges and other flying insect nuisances.

Section 3. BEDBUGS

B3.01 GENERAL

1. DESCRIPTION AND DEVELOPMENT. A fully grown bedbug is a flattened, reddish brown, wingless, sucking insect averaging 3/8 inch in length (Figure 22). It develops from eggs laid in wall cracks, furniture, mattresses, or other sheltered places. The eggs hatch in about 6 days and, if a suitable source of blood is available, the young bugs begin feeding and growing. Under favorable conditions (warm temperatures and available food) they mature and lay a new generation of eggs in a little over 30 days. Breeding continues the year around in warm regions and uniformly heated quarters. Adult bugs live from 6 to 8 months and may even survive without food for several months in unoccupied and unheated buildings. The female bedbug lays between 75 and 500 eggs during her lifetime.

2. DISTRIBUTION. Heavy bedbug infestations may be found not only in unclean houses but in barracks and other spotlessly clean buildings, and are found in many places, such as infested beds, mattresses, furniture, and luggage (Figure 23). They may cling to the clothing of persons in motion picture theaters, hotels, trains, and buses. They have a nearly world-wide distribution indoors in close association with man.

3. FEEDING. Bedbugs do not require filth in which to breed, but must have the blood of humans or some other suitable host animal, such as a rabbit, mouse, rat, or fowl. They are readily disturbed while feeding so they normally feed upon sleeping persons at night (Figure 24).

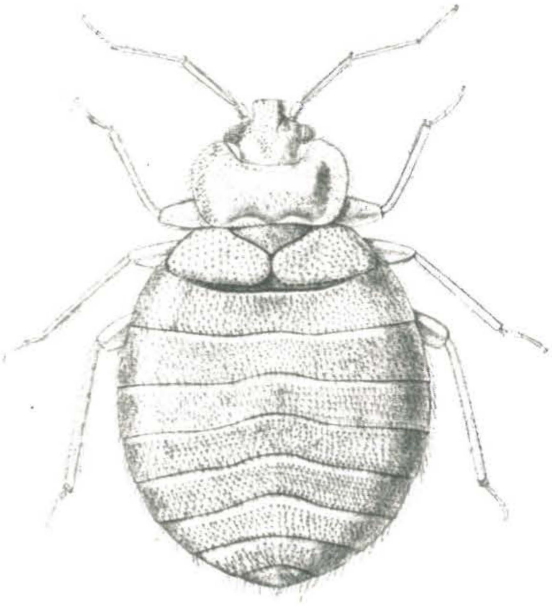


FIGURE 22

Full-Grown Bedbug

FIGURE 23

Bedbugs Hide in Rolled Edge of Mattress

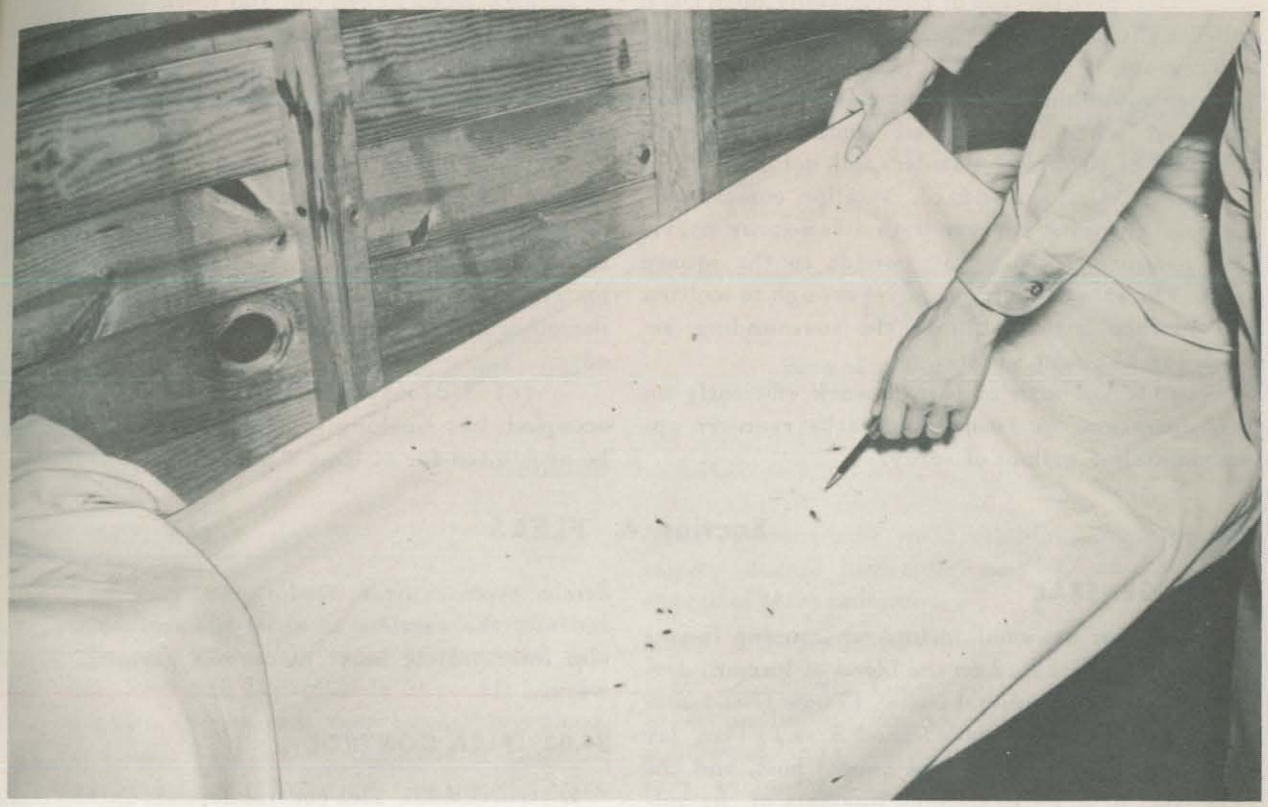


FIGURE 24

Bloodstains on Sheet as Result of Feeding by Bedbugs

B3.02 BEDBUG CONTROL

1. GENERAL. Applications of sprays containing DDT are highly recommended for bedbug control. Fumigation with hydrocyanic-acid gas was formerly recommended for this purpose, but it has no lasting effect and is dangerous to use. When properly applied, DDT will keep mattresses free of bedbugs for 6 months or more.

2. PREPARATION OF QUARTERS.

(1) Cover, or remove from the areas to be treated, all clothing, rubber material (such as gas masks), and other objects to be protected from kerosene. Do not remove mattresses, bedding, chests, or any other items which may be infested, or the bedbugs may be spread to new locations.

(2) Move beds far enough away from the wall to permit spraying the wall surface.

(3) Fold mattresses over endwise and place them in the center of each bed at an angle of 45 degrees (Figure 25).

3. APPLICATION OF INSECTICIDE.

(1) Observe safety precautions outlined in paragraph B14.03.

FIGURE 25

Spraying Beds

(2) Five percent of commercially pure DDT powder dissolved in kerosene is the spray material (paragraph 4 of B14.02). (Dusting or delousing powder containing 10 percent DDT should not be confused with concentrated commercially pure DDT. The delousing powder will not dissolve in kerosene.) Use a standard, 3-gallon compressed-air or a knapsack sprayer with a fan-spray nozzle and pressure of 25 or 30 pounds to the square inch. The spray should be coarse enough to moisten the surface without filling the surrounding air with fog-like mist.

(3) A 2-man crew can work efficiently on this operation. A 70-man barracks requires approximately 5 gallons of spray.

(4) Begin at one end and work around room spraying cracks, wall beams, and other likely bedbug locations to a height of about 4 feet from the floor (6 feet if double-tier beds have been placed against wall).

(5) Proceed along a row of beds spraying one end of each bed (principally spring coils and corners) and one folded edge of each mattress. (It is not necessary to treat the flat surfaces of the mattresses.) Return up the other side, spraying the other end of each bed and remaining mattress edges.

(6) Beds may be made up after 4 hours and occupied, but smoking in treated barracks should be prohibited for at least 6 hours.

Section 4. FLEAS

B4.01 GENERAL

Adult fleas are small, wingless, jumping insects (Figure 26) that feed on the blood of human, dog, rodent, and other animal hosts. (Those found outdoors are frequently called sand fleas.) They lay their eggs in the hair of the animal host, and the eggs later drop off in sleeping quarters of the animals, on floors, and on the ground outdoors. Small, worm-like larvae (Figure 27) hatch, feed on organic debris, and become adult fleas in from 2 to 11 weeks, depending on conditions such as warmth and the kind of flea it is.

Fleas are extremely dangerous because they transmit diseases such as bubonic plague and endemic typhus after feeding on rats and field rodents, the carriers of those diseases. They are also intermediate hosts to certain parasitic tapeworms.

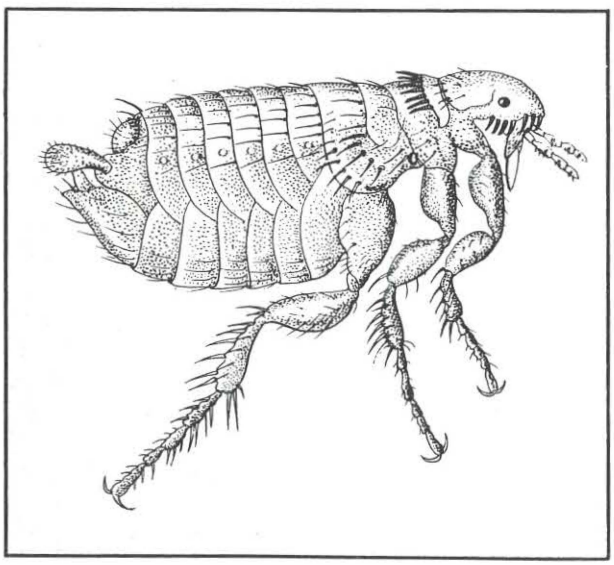


FIGURE 26

The Dog Flea

B4.02 FLEA CONTROL

1. GENERAL. Flea control depends on (a) control of rats; (b) elimination of fleas from domestic animals, particularly cats and dogs; and (c) treatment of areas where fleas breed.

2. ELIMINATION OF RATS. Rats should be controlled not only because they destroy property and supplies, but because they transmit diseases to humans through the fleas, which feed on both. (Refer to directions for rat control in paragraph C1.04.) Dust rat burrows with 10-percent DDT powder before starting rat control to prevent fleas from leaving dead rats to migrate to other animal hosts or humans.

3. DESTRUCTION OF FLEAS ON DOMESTIC ANIMALS. Stray cats and dogs should be eliminated because they are likely to be a source of flea infestations. Pet animals should be kept out of barracks, offices, and storage places. Fleas on dogs may be killed by rubbing 10-percent DDT powder (Navy Stock No. G 51-I-156-50) well into the fur. One quarter of a teaspoon is enough to treat a dog of average size. Fleas on cats may be killed by dusting the animals with derris or pyrethrum powder. Do not treat cats with DDT powder because of the danger of poisoning.

4. TREATMENT OF BREEDING AREAS. Bedding on which cats and dogs sleep, the surface

and cracks beneath, and floors of rooms frequented by the animals should be treated to kill adult fleas and their young stages. Floors, rugs, and wall surfaces, to a height of 2 feet from the floor, should be sprayed with 5-percent DDT residual spray at the rate of 1 quart for every 250 square feet. The dosage is almost doubled for earthen floors and beneath buildings. Spray equipment used for bedbug control is suitable for spraying flea-breeding areas. Grassy areas infested with fleas should be dusted with 10-percent DDT powder applied with a rotary hand duster, ½ pound to 1,000 square feet. Gamma isomer, 0.5 BHC, may be applied to infested grounds and under buildings at the rate of 10 to 20 gallons per acre.

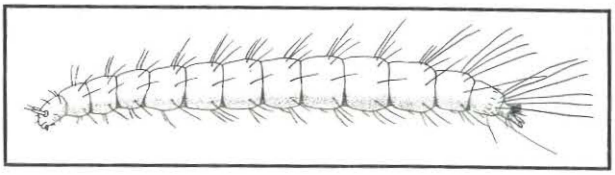


FIGURE 27

European Rat Flea Larva

Section 5. LICE

B5.01 GENERAL

Human lice infest only human beings, and transmit epidemic typhus fever and a number of other diseases. There are three kinds, head lice, body lice, and crab lice (Figure 28). All are active, wingless insects that feed by sucking blood. The head louse lives among the hairs of the head and attaches its eggs (known as nits) to the hairs. The body louse feeds on the body, although when not feeding it remains chiefly on the clothes next the skin and lays its eggs in the clothing (Figure 29). The crab louse lives among the hairs of the pubic region, less often in other hairy regions of the body, and occasionally in the beard and eyebrows. Lice can not live more than from 7 to 10 days away from human warmth and blood. They breed rapidly and are spread by contacts with infested persons and their clothing. Because lice convey disease organisms, medical officers have charge of their control.

B5.02 LOUSE CONTROL

1. GENERAL. Louse control includes delousing of the individual, the treatment of clothing and equipment, ships, and other vehicles used by military personnel and prisoners of war. Control operations should be closely supervised by medical personnel.

a. Cleanliness. Personal cleanliness is of prime importance in preventing louse infestation, including bathing with soap and water at least once a week, and changing the clothing, particularly the underwear.

b. Personal Contact. Unnecessary contact with persons likely to be infested, such as prisoners

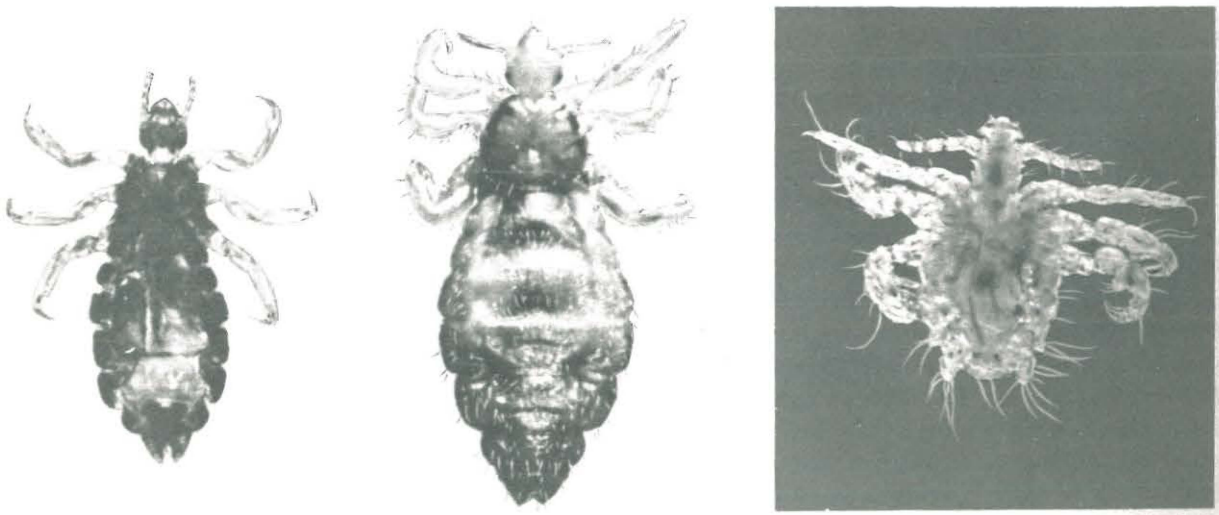


FIGURE 28

Three Common Forms of Human Lice

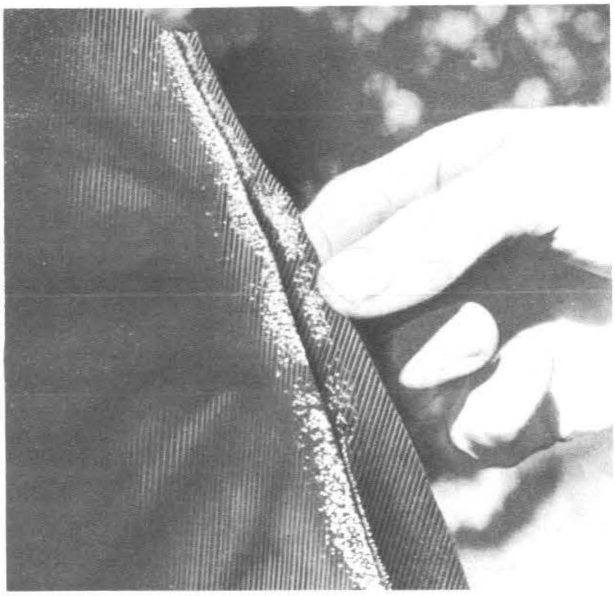


FIGURE 29

Eggs of Body Louse Deposited Along Seam of Trousers

of war, should be avoided. The body and clothing should be inspected weekly, or oftener.

2. INDIVIDUAL DELOUSING. Louse powder, Pyrethrins and Synthetics (QMC Stock No. 51-I-195), is a mixture developed especially for louse control and is issued in 2-ounce, sifter-top cans ready for individual use. It may also be obtained in 4-pound (QMC Stock No. 51-I-197) and 20-pound (QMC Stock No. 51-I-199) cans. The powder is safe to apply directly on the body.

a. Treatment for Body Lice. For prevention or treatment of body-louse infestations, sift louse powder over the entire inner surface of underwear and any other clothing worn next the skin, including the shirt. Give special attention to the seams, areas about the neck, armpits, waist, shirt tail, and crotch of pants. Dust along the seams of the outer garments and the inside of caps. Rub the treated clothing lightly to spread the powder. About 1½ ounces of powder are required for one person and his clothes. The application should be repeated after each change of clothing. If clothing can not be removed conveniently for treatment, unbutton the shirt and trousers and dust the powder liberally on the inside of the underwear or other garments next the skin, then pat the clothes with the hands to ensure more even distribution of the powder. Eggs of lice are not affected, but the young lice are killed soon after hatching. Lice may not be killed for several hours after dusting. The treatment is effective for 3 weeks if the clothing is not washed.

b. Treatment for Head Lice. For head lice, dust the powder lightly into the hair and rub in thoroughly with the fingertips. The eyebrows and beard (if any) also should be treated. Do not wash hair for at least 24 hours. Since the eggs are not killed by the first application, treatment must be repeated a second and third time at weekly intervals to kill young lice hatching from the eggs.

c. Treatment for Crab Lice. Although most frequently occurring in the pubic region, crab lice are often found on other areas of the body. Apply the powder thoroughly to all regions of the body having a moderate-to-heavy growth of hair. Do not bathe for at least 24 hours, and repeat application twice at weekly intervals.

3. MASS DELOUSING. Lindane dusting powder (QMC Stock No. 51-I-188-75) is a mixture containing 1 percent lindane primarily for use in special problems of mass delousing with hand and power dusters. The use of such mechanical dusting equipment obviates the need of disrobing.

a. Hand Dusters. A plunger type of hand duster delivers an even flow of powder. Best results are obtained when the duster reservoir is only three-fourths filled. This quantity will treat about 10 individuals.

b. Power Dusters. Power dusting equipment (Specification No. MIL-0-2457, QMC Stock No. 66-0-800, Outfit, delousing, gasoline engine-driven) consists of a small portable gasoline engine, an air compressor, 10 lengths of hose, and 20 dusters. Extra units are supplied to enable refilling while the apparatus is in use. One complete unit is capable of delousing 600 persons in an hour. The equipment is especially suitable for troops in rear areas, prisoners in prisoner-of-war enclosures, and civilians in occupied territory.

c. Procedure. A definite dusting routine should be followed in accordance with directions of the medical officer to avoid missing portions of the clothing and body.

4. TREATMENT WITH DELOUSING SPRAY. Delousing spray (QMC Stock No. 51-I-310) is a stock solution consisting of 6 percent DDT, 68 percent benzyl benzoate, 12 percent benzocaine, and 14 percent emulsifier, the so-called NBIN formula. The stock solution must be diluted with

five times its volume of water to form a 1-percent DDT emulsion, be mixed only in sufficient quantity for estimated needs, and be used within 24 hours.

Delousing spray to kill both the lice and their eggs is used primarily when immediate and complete disinfestation is desired. It is also used in conjunction with methyl-bromide fumigation or steam sterilization of clothing and equipment when individuals are required to bathe before treatment. It is not intended to replace regular treatments with louse powder, and is applied only under the supervision of the medical officer.

5. DISINFESTATION OF CLOTHING. There are several methods of killing lice and their eggs in clothing. The chief one where lice are not DDT resistant is DDT impregnation because it has the advantage of some residual effectiveness. When impregnation facilities are not available at advanced bases, however, clothing may be fumigated with methyl bromide. Steam sterilization was formerly the standard method of delousing clothing and may still be used in an emergency. The disinfestation of clothing in louse control is done under the direction of the medical officer.

Section 6. MITES

B6.01 CHARACTERISTICS OF MITES

1. HUMAN ITCH MITE. Human itch mites burrow in the skin, causing the condition or disease known as scabies, or itch. They are acquired through close contact with infested persons. (See Figure 30.)

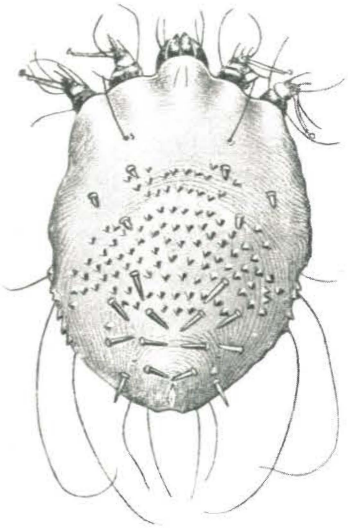


FIGURE 30

Human Itch Mite (Female) Magnified 100 Times

2. CHIGGERS. Chiggers, commonly known as red bugs, include a number of species of *Trombicula*. They are widely distributed in the eastern half of the United States but are most numerous in the southern states and southward into Mexico. When young, the tiny mites normally feed on animals such as birds, mice, and rats. (Scrub typhus, or tsutsugamushi disease, recorded on the Asiatic mainland from Korea to India, and from

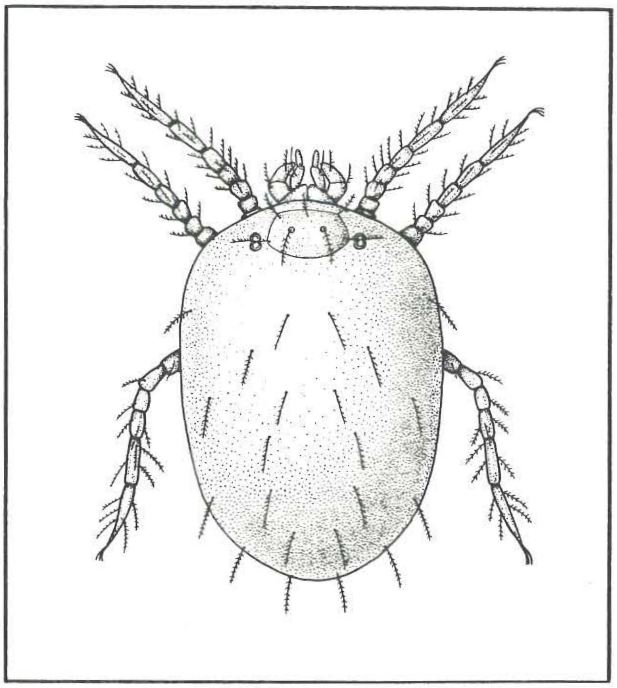


FIGURE 31

Chigger

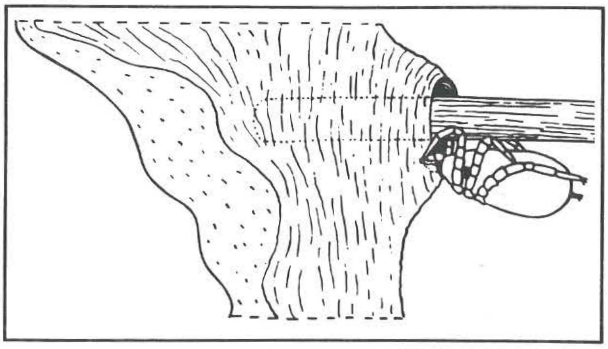


FIGURE 32

Chigger Attached to Skin at Hair Follicle

Japan, the Philippines, New Guinea, Indonesia, and northern Australia, is carried from rodents to man by species of *Trombicula*.) They attach themselves to the skin of humans, usually close to a hair, and inject an irritating fluid that causes intense itching for several days after the mite has dropped off or been removed (Figures 31 and 32). Only the young mites feed on animals and humans. Except when feeding, mites usually occur from 2 to 3 inches below the surface of the soil to about 3 inches above the surface in ground litter.

3. MITES AS PESTS IN STORED FOOD PRODUCTS. (See Section 11.)

B6.02 MITE CONTROL

1. ITCH MITES (SCABIES). Infested individuals should be treated by a medical officer. Treatment may be with delousing insecticide (Stock No. 51-I-310) diluted with water to five times its volume, as in louse control (paragraph 4 of B5.02).

2. CHIGGER CONTROL. Chiggers may be detected simply by standing in a suspected spot. The small yellowish or pinkish mites will crawl rapidly over the shoes if present.

a. Area Treatment. Vegetation shading the ground and maintaining a high moisture level at the soil surface should be cleared from camp sites, by hard labor if necessary. This is especially important in scrub typhus areas and should be done with a minimum of personnel exposure to infestation. Fuel oil sprayed over the freshly cleared ground at the rate of 40 gallons per acre eliminates mites from the area for at least 1 day.

A chlordane-emulsion concentrate spray (46 percent chlordane), diluted with water to contain about 1 percent chlordane, may be used in limited areas, such as lawns, recreation areas, and selected portions of military posts, but its use should be supervised by trained personnel. The diluted spray is applied to ground litter at the rate of 10 to 20 gallons per acre. Cylindrical or knapsack-type sprayers are suitable for small areas, but power equipment is more satisfactory for large areas. This treatment should be effective for from 1 to 2 weeks.

Benzene hexachloride-emulsion concentrate may be used in place of the chlordane concentrate. It should, however, be diluted to 0.5 percent of strength. With this exception, it should be applied the same as directed for chlordane.

b. Impregnation of Clothing. Under supervision of medical personnel, garments may be chigger-proofed to withstand several launderings by using an emulsified mixture of repellent chemicals. The available chemicals vary as to the dilution necessary and to their ability to withstand laundering.

c. Treatment of Personnel. When area control or clothing impregnation is impractical, personnel may be protected by simple skin and clothing treatments with a repellent. The chemical should be applied in accordance with directions of the medical officer.

Section 7. TICKS, SPIDERS, AND MISCELLANEOUS ARTHROPODS

B7.01 TICKS

1. GENERAL. Ticks attach themselves firmly, by the beak, to the skin of man and animals to obtain blood for nourishment, and the victim is often unaware of their presence. The Rocky Mountain wood tick and the American dog tick (Figures 33 and 34) are the most prevalent tick carriers of human disease in the United States (they may cause tick paralysis and transmit Rocky Mountain spotted fever, relapsing fever, and tularemia), although several kinds of *Ornithodoros* ticks carrying relapsing fever in the west and southwest. The brown dog tick may occur in large numbers on dogs and be a pest indoors where dogs are kept, but it does not bite man.

2. HABITS AND DEVELOPMENT. In general, ticks are hard or tough, wingless, and lay their eggs on the ground. The young (seed ticks) seek out host animals on which to feed after hatching, and when gorged with blood drop to the ground. The number of feedings varies with different tick species and different host animals.

The American dog tick is most abundant along the Atlantic coast and some middle-western areas (Figure 33). Adults prefer feeding on dogs but also feed on other large animals and man, while the young feed principally on mice. The Rocky Mountain wood tick, most numerous in the northern part of the Rocky Mountain region of the United States, develops in much the same way as the dog tick. The young ticks, however, appear to attach themselves to a wider variety of rodents, such as chipmunks, ground squirrels, and wood-

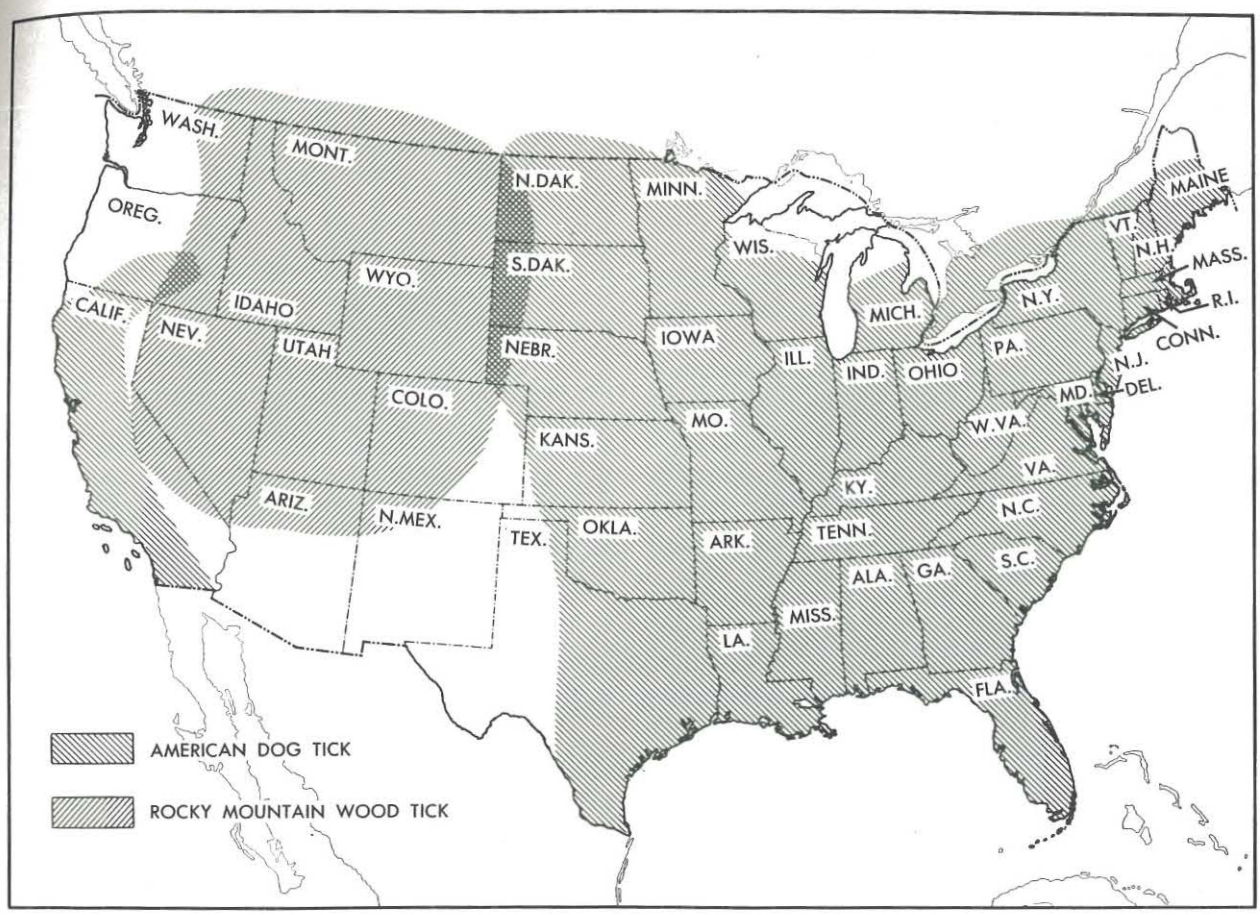


FIGURE 33

Distribution of American Dog and Rocky Mountain Wood Ticks

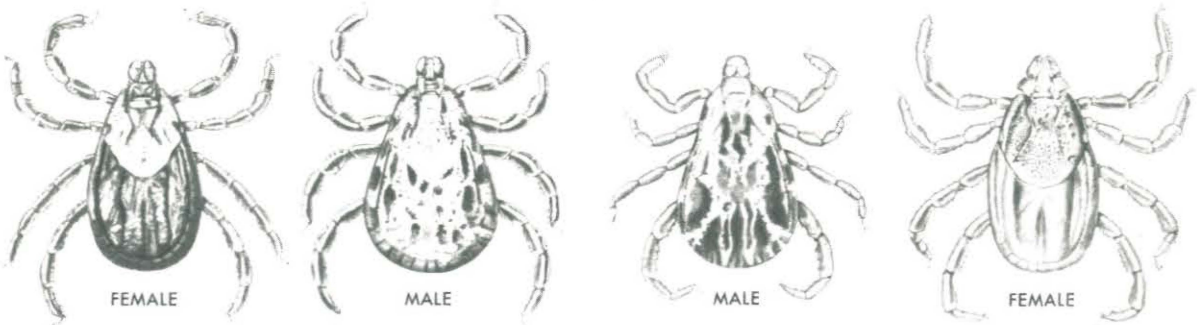


FIGURE 34

Comparison of Common Ticks

chucks. Both kinds transmit Rocky Mountain spotted fever and tularemia. *Ornithodoros* ticks feed on various native rodents, snakes, terrapins, and domestic animals, as well as man.

3. AVOIDANCE OF TICK ATTACK. Precautions should be taken in tick-infested areas to avoid bites and possible disease infection. High-top shoes, leggings, or socks pulled up over the bottom of the trousers help to keep ticks from crawling beneath the clothing. Outer clothing should be examined occasionally to remove ticks before they reach the belt or neckline, and both body and

clothing should be examined before retiring. Do not allow ticks to move from infested clothing to bedding or fresh clothing.

Ticks on the body are easily overlooked, especially on hairy parts and particularly on the back of the head. Prompt removal of attached ticks in accordance with instructions of the medical officer will prevent the possible development of tick paralysis. *Ornithodoros* ticks do not crawl about on the body as long as the Rocky Mountain and American dog ticks before attaching themselves to the skin, and may remain attached for only a few minutes. One species of *Ornithodoros* frequents dry limestone caves in Texas; hence caves, overhanging banks, rock ledges, and similar places in infested regions should be avoided. Other species frequent dry woods and rodent burrows and occasionally invade cabins.

4. AREA TREATMENT.

a. Removal of Vegetation. Clearing vines and underbrush from wooded places, and brush, grass, and weeds from open areas, reduces tick prevalence and is recommended.

b. Use of Insecticide. In areas where low brush can not be cleared or its removal does not adequately reduce tick population, ground litter and low vegetation may be sprayed with a 0.5-percent BHC spray at the rate of 10 to 20 gallons per acre. Heavy applications of DDT along roadsides and trails have proved effective.

5. REPELLENTS. Treatment of the person and clothing as directed for repelling mites (Section 6) will often provide protection against ticks.

B7.02 SPIDERS

1. GENERAL. Spiders seldom bite and then only when provoked, as when the hand squeezes a spider hiding in a glove. On the North American continent only the bites of the black widow spider and certain tropical tarantulas appear to cause serious poisoning of human victims. The black widow (Figure 35) is widely distributed over the United States, is shiny black with a red or yellow-red hourglass on the underside, and usually is found in sheltered places outdoors, such as rodent burrows, and sometimes in garages and basements.

2. SPIDER CONTROL. Where spiders become numerous, measures may be required for their control. Spider webs should not be permitted to remain in outbuildings and storage rooms. Return of spiders to such locations can be largely prevented by spraying cracks and corners with 2-percent chlordane insecticide, 5-percent DDT solution, or 0.5-percent lindane emulsion. This should be done immediately after removal of cobwebs so the spray will reach the spiders while they are still unprotected. When removing spider webs, all egg sacs should be crushed.

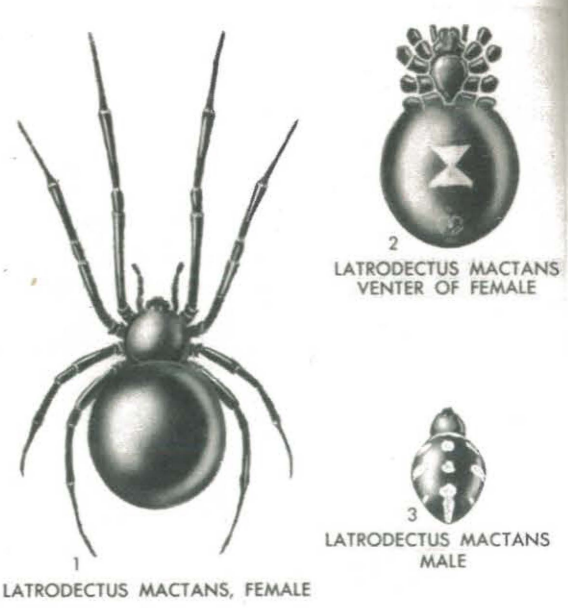


FIGURE 35

Black Widow Spider: 1, Female; 2, Hourglass Marking on Underside; 3, Marking on Upperside of Male

B7.03 SCORPIONS

1. GENERAL. Scorpions, like spiders, sting man only under provocation, but are not thought to transmit disease. Various kinds of scorpions occur in the southern United States west to California and are a problem chiefly in tropical regions. They are commonly 2 or 3 inches long, with a pair of pincers in front and a long slender abdomen terminating in a swollen stinger, and hide under stones and trash outdoors or sometimes in dark crevices indoors during the day.

2. SCORPION CONTROL. Application of 2-percent chlordane insecticide, as for the control of cockroaches and spiders, will kill scorpions in, or keep them from entering, treated buildings.

B7.04 CENTIPEDES AND MILLIPEDES

Centipedes are long, worm-like, active creatures with many legs, one pair to each body segment,

that sometimes bite human beings, but their bites seldom cause serious discomfort. Millipedes differ from them in being cylindrical, rather than flattened, and in possessing many more legs, but, especially the larger tropical species, often secrete a fluid that may be strongly irritating to the skin and eyes.

B7.05 STINGING INSECTS

1. GENERAL. Insects that sting include the honeybee and bumblebee, wasps and hornets, and various ants. Bees leave the stinger in the flesh of the victim. The stinger should not be picked out between the fingers because this procedure forces the venom into the flesh. Rather, the stinger should be removed by squeezing the flesh as in removing a blackhead or by flicking it off with a fingernail or knife blade. Wasps and ants do not leave their stingers in the wound.

2. WASPS. Paper wasps and hornets often build their nests on outer wall surfaces, under eaves, and in the attics of buildings, and may attack passing persons, especially if the nest be disturbed. Mud-dauber wasps are also a nuisance because their small mud structures on the ceilings of porches and other places are unsightly. Control of wasps is best done at night, when the adults have returned to the nest and are drowsy. Fuel oil, kerosene, or a 5-percent kerosene solution of DDT should be liberally sprayed or otherwise applied directly on the nest. If a large paper nest is in a favorable location, a liberal amount of the spray liquid may be poured directly into a hole made in the nest from above.

3. HONEYBEES. Honeybees sometimes locate their nest in the wall of a building and therefore require destruction. As much insecticide as practicable should be forced into the nest opening at night, following which the entrance is sealed with masking tape, cork, doweling, or other means. Thus, the chemical is confined, the bees are prevented from escaping, and other bees can not establish themselves in the same location. In places where the stores of honey in the bee nests may cause damage by staining walls or attracting other insects, the wall should be opened up and the nest contents removed and destroyed. This should be done several days after treatment, when the bee swarm is dead. Repair work should be such as to prevent a recurrence of the infestation.

4. BUMBLEBEES AND YELLOW JACKETS. Bumblebees and yellow-jacket wasps usually build their nests in holes in the ground. When their nests are located so as to be objectionable, liberal applications of wettable DDT suspension will subdue them.

5. CARPENTER BEES. Carpenter bees tunnel into unpainted beams, rafters, telephone poles, fence posts, or other structural timber. The tunnel is divided into cells, in each of which an egg is laid and a supply of pollen stored for the bee larva to feed on. Ordinarily, damage done by carpenter bees is of little consequence, but repairs may be necessary if colonies form year after year in the same timbers. Dusting partially finished tunnels with 10-percent DDT powder will kill the adult bees and check the damage.

6. STINGING ANTS. Stinging ants are very annoying in some parts of the southern United States and in tropical and subtropical regions. The imported fire ant is a field species, occurring in some of the southeastern states, that inflicts a painful wound that may persist for several days. The red harvester ant is found in the southwestern states. To avoid either bites or stings in ant areas, wear high boots or tuck the trouser legs in the shoes; also stamp the feet on the ground frequently to dislodge ants. (See Section 9 for directions for ant control.)

Section 8. COCKROACHES

B8.01 GENERAL

Cockroaches are a major problem at Navy shore stations. They commonly infest mess rooms, post exchanges, hospitals, galleys, and barracks, and ordinarily are found around steam tables, sinks, floor drains, shelving, food storage, double walls, latrines, and steam tunnels. They contaminate food, tables, food carts in hospitals, shelves, and similar places. There are several kinds, but all are similar in appearance, habits and control (Figures 36 to 39), breed rapidly in the presence of food and warmth, shun the light, and are most active at night. During the day they hide in cracks and other places of concealment. They run rapidly out

of sight when disturbed, traveling over considerable distances within buildings to sources of food and water. In warmer climates, they wander to some extent outside the shelter of buildings. Certain less domesticated species of cockroaches habitually live outdoors around decaying organic matter and may invade nearby buildings.

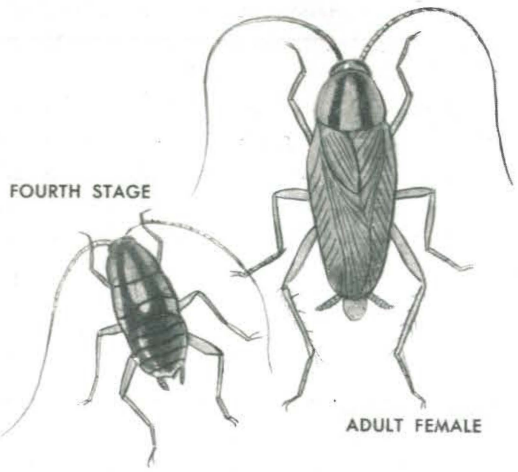


FIGURE 36

German Cockroach

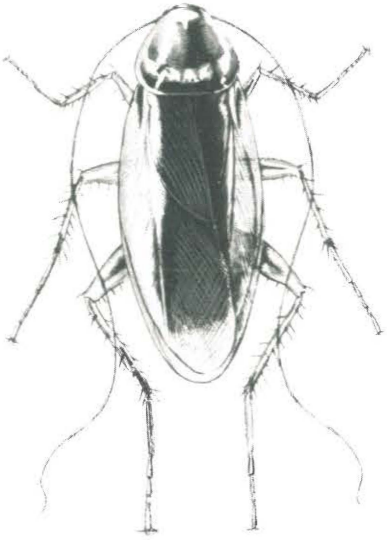


FIGURE 37

American Cockroach

Cockroaches are long-legged, flat-backed, foul-smelling insects. All have a pair of long, slender feelers on the head. The larger kinds (American and Oriental) are 1 or 2 inches long and a dark, shiny brown or black when full grown. The smaller ones (German and brown-banded), when mature, are but little over ½ inch long, and are lighter shades of brown with striped markings. Cockroaches lay eggs in small, brown cases in their hiding places, from which are hatched small, wingless cockroaches that run and feed with the adult insects.

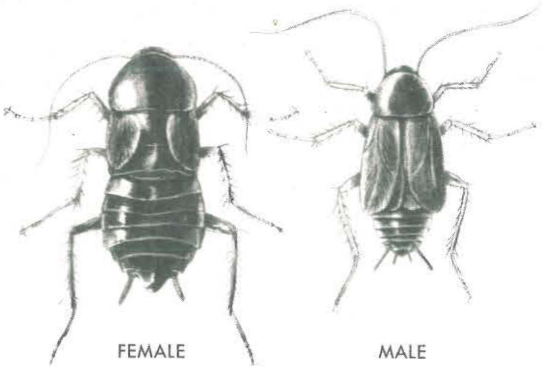


FIGURE 38

Oriental Cockroach

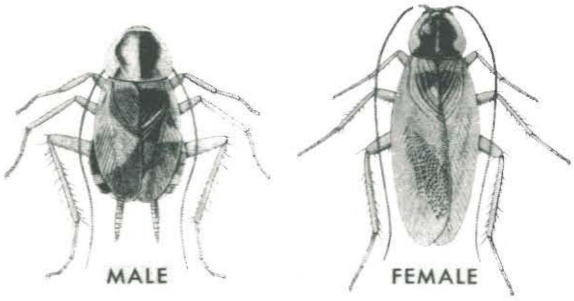


FIGURE 39

Brown-Banded Cockroach

B8.02 CONTROL

1. GENERAL. Control necessitates a continuing program of thorough cleanliness, protection of food supplies, elimination of hiding places so far as possible, and the use of effective insecticides. Chlordane sprays are effective, having a residual effect similar to that of DDT sprays, but are not nearly so long-lasting as the latter. Repeat treatment as roaches reappear, or every 3 months.

Dusting with DDT powder is only moderately effective. (See paragraph B14.02.)

2. PREVENTION OF BREEDING. Remove all food scraps from tables, shelves, and floor surfaces, and from behind and beneath equipment. Destroy hiding places by filling cracks with putty, cement, or plaster, and by removing unnecessary quarter-round and trim behind which roaches may hide. Prevent their free movement by closing crevices and openings where pipes pass through walls and floors. Keep galleys and storerooms dry and well ventilated. Do not allow organic matter to accumulate and mold or decay beneath or around buildings. Construction should be planned to eliminate, insofar as possible, cracks and other locations favoring the hiding and running of cockroaches.

3. INSECTICIDES. Observe safety precautions stated in paragraph B14.03.

Remove all food, dishes, and movable cooking utensils from the room during treatment. Carefully cover food preparation tables and similar nonmovable items. Spray liquid insecticide containing 2-percent chlordane liquid (Navy Stock No. G 51-I-155-375, 1-gallon container or G 51-I-155-385, 5-gallon container) with standard 3-gallon compressed-air sprayer or other suitable equipment. Use a coarse, wet spray to avoid fogging, and hold the nozzle 8 or 10 inches from the crack or surface being sprayed. Treat all protected areas and crevices where cockroaches travel and hide, such as beneath and behind sinks, cupboards and tables, around drainpipes, upon shelves, behind baseboards, and in any nearby cracks in walls. Use approximately 1 gallon per 1,000 lineal feet of cracks or 1 pint per 125 lineal feet. Spray until the surface is wet but not dripping, and force the insecticide into hiding places of the insects.

A kerosene spray containing 5 percent DDT may, if necessary, be substituted for the 2-percent chlordane spray. It is not so effective against smaller kinds of cockroaches, but lasts longer against the larger kinds.

Dust 10-percent DDT dust (Navy Stock No. G 51-I-157-600, 5-pound can, or G 51-I-157-610, 25-pound drum) with a plunger, bulb, or bellows duster into places frequented by cockroaches. (The dust should not be swept up or wetted when it is applied to locations where it will not contaminate food.) Frequently, the use of both spray and dust is advantageous, spray being applied to the under surfaces of tables, and so on, and dust being blown into cracks and behind walls.

Section 9. ANTS

B9.01 GENERAL

There are various species of ants, each with its own habits. Most live in underground colonies. Others nest in building-wall spaces, under loose flooring, or other protected places. Those that build mounds of dirt above the ground surface are a problem at airfields and on grassed areas (Section 12). Many that live in nests carry food back to the colony from mess halls, bakeries, barracks, storage warehouses, and so on (Figure 40). Some sting viciously, causing painful wounds.

Typical ant colonies include a queen that lays the eggs from which ants develop, and a large number of worker ants that construct the nest, bring food, and care for the queen and its young. Some ant species may have more than one queen in a colony. Ants are visible around nest openings and along routes to and from sources of food, and nests may often be located by tracing an ant trail.

B9.02 ANT CONTROL

1. GENERAL. Effective ant control should include destruction of queens and young ants. Poisons may be carried back to the nest on the bodies of worker ants or in the food they transport. If sufficient workers are eliminated, the colony may be weakened or killed by starvation.

2. CONTROL INDOORS. Foods that attract ants must be covered, and crumbs and food wastes must not be permitted to accumulate on surfaces and in cracks. Sweet and greasy films on shelves and tables should be removed because they also attract ants.

a. DDT Insecticides. Residual spray containing 5 percent DDT in refined kerosene is effective against many species of ants. The spray should be applied liberally to ant trails and around window sills, steps, door frames, and baseboards. When 10-percent DDT powder is used, it should

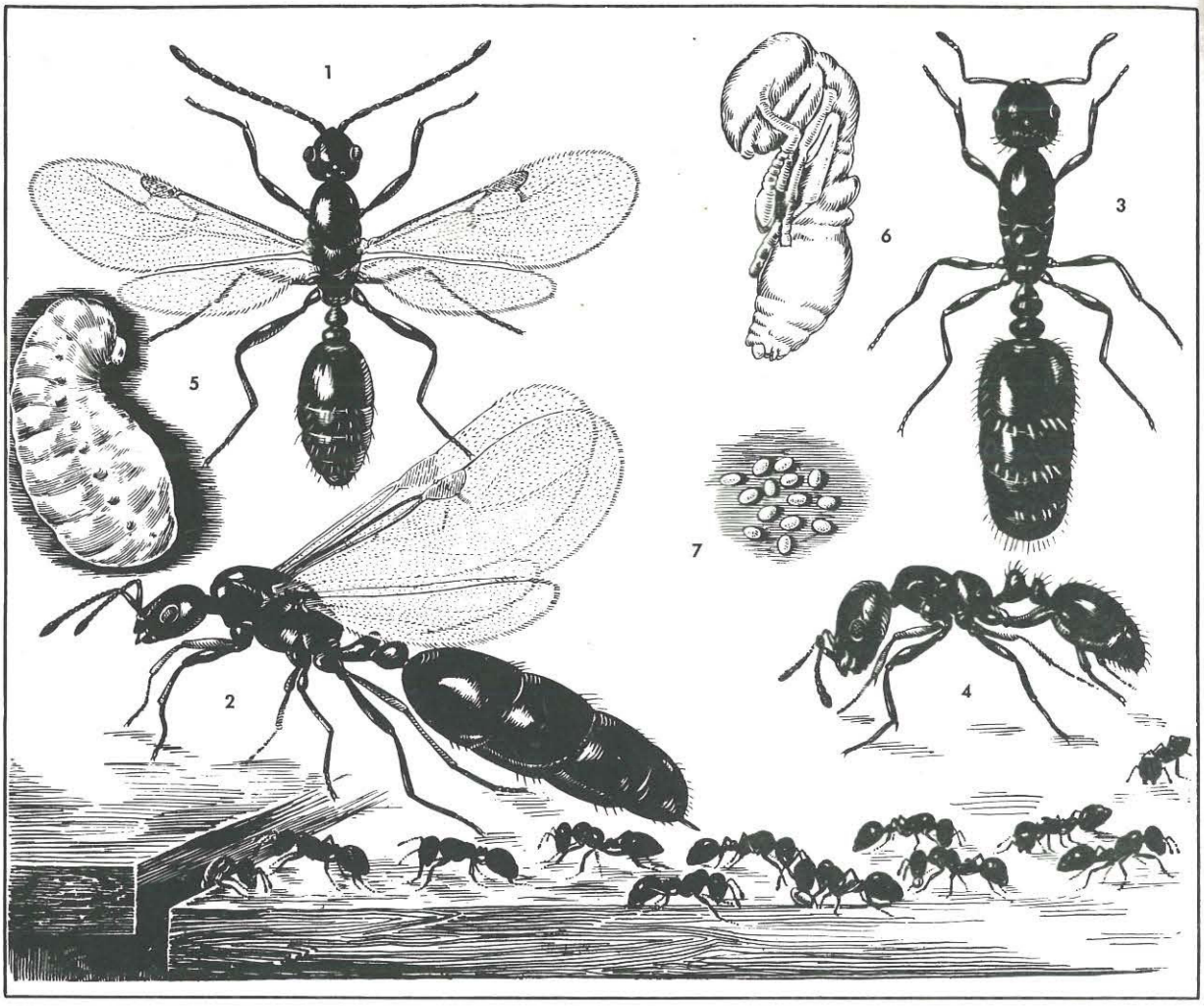


FIGURE 40

The Little Black Ant: 1 and 2, Winged King and Queen; 3, Queen After Losing Wings; 4, Workers; 5, Larva; 6, Pupa; 7, Eggs

be applied lightly along trails with a plunger-type duster. The dust should also be blown into cracks where ants may find shelter.

b. Lindane. Under supervision of trained personnel, a 0.5-percent lindane emulsion may be substituted for the kerosene DDT solution. It should be sprayed on surfaces to a point just short of runoff.

c. Chlordane Insecticides. Chlordane is very effective, but should be used only when authorized and then in accordance with precautions outlined in paragraph 2 of B14.02. The residual effect of chlordane deposits is not so long-lasting as that of DDT, but in sheltered places, such as cracks in woodwork, it acts as a fumigant. Use 2 percent strength, either in kerosene solution or as an emulsion, and apply it to runways and wall openings from which ants emerge, or directly to the nests if they can be located.

3. CONTROL OUTSIDE.

a. Chlordane Emulsion. Emulsifiable chlordane concentrate (46 percent) may be diluted to a 1 percent strength and sprayed, under supervision of trained personnel, on infested ground areas and individual ant hills. Spray at the rate of 1 to 2 gallons on large individual mounds from 1 to 2 feet high and 2 feet or more in diameter, also spraying the surrounding area within 2 or 3 feet. Over large areas, the spray should be applied

at the rate of 30 to 50 gallons per acre. Water thoroughly after treatment to increase effectiveness of the treatment and to reduce the hazard to children and animals that might enter the area.

b. Chlordane Solution in Oil. If there is no vegetation, 2 percent chlordane in kerosene may be applied to ant runways and nests outside and beneath buildings. On lawns or other areas where the kerosene is likely to cause plant injury, water suspensions (emulsions or water-dispersible powders) or dusts should be used.

c. Water-Dispersible DDT Powder. Wettable DDT powder (Navy Stock No. G 51-I-157-75) may be prepared and sprayed as a suspension containing 2.5 percent DDT to thoroughly wet ant runways and nests.

d. DDT Dust. Ten-percent DDT powder (Navy Stock No. G 51-I-157-600) may be applied on and around ant nests and along runways. Treatment should be repeated after each rainfall.

Section 10. TERMITES

B10.01 TYPES OF TERMITES

There are two types of termite in the United States, subterranean and dry-wood. Subterranean termites often work in wood aboveground but must have direct communication, by means of their tunnels, with the underground colony. Dry-wood termites develop in wood located away from the soil and sources of moisture.

B10.02 OCCURRENCE AND CHARACTERISTICS OF SUBTERRANEAN TERMITES

1. DAMAGE. Subterranean termites annually cause building damage amounting to many millions of dollars in the United States. To avoid heavy losses, designs for new construction should embody certain simple and effective preventive measures. In older buildings which were not so con-

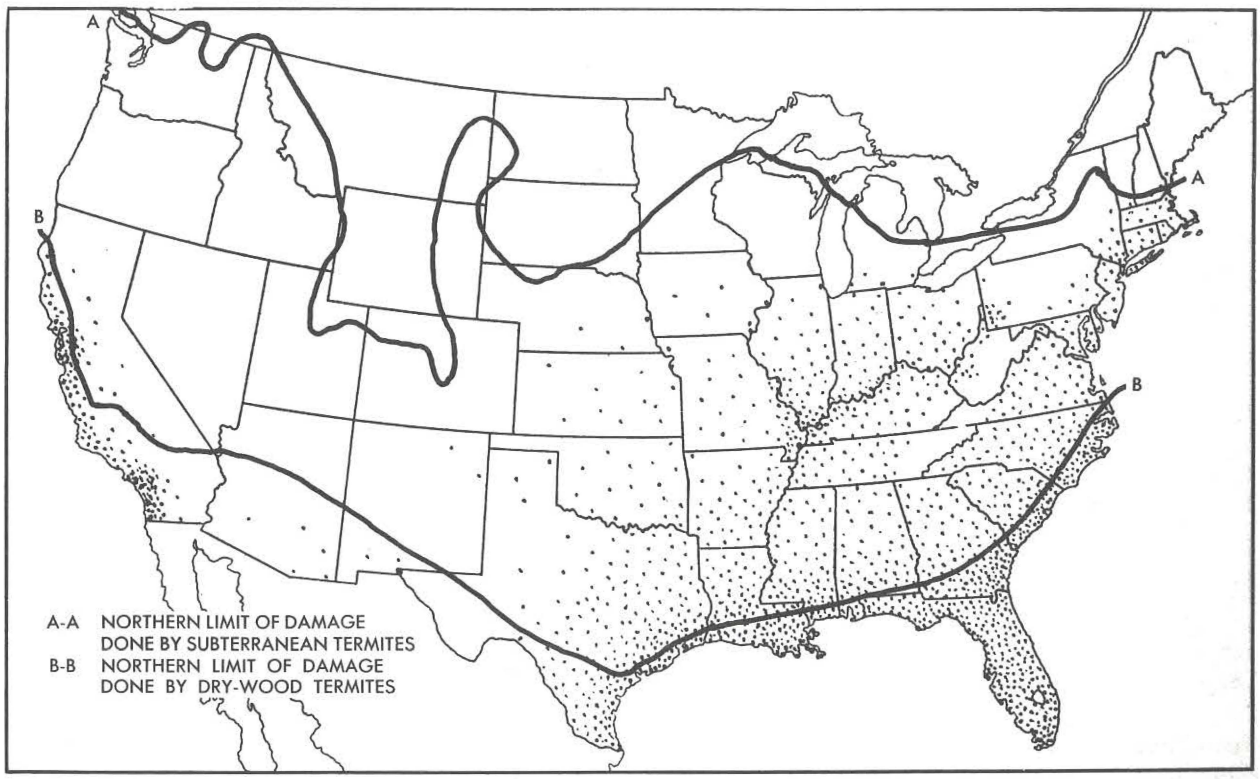


FIGURE 41

Map of the United States Showing Distribution (by Density of Stippling) of Subterranean and Dry-Wood Termite Infestation

structed, steps for termite control should be taken promptly when inspection reveals infestation.

2. DISTRIBUTION. Subterranean termites may be found almost anywhere in the tropical and temperate zones of the world. They are most destructive in the United States in areas of high moisture along the Atlantic coast, in the Ohio and Mississippi River valleys, and in southern California. They may, however, cause severe damage elsewhere in their geographical range. Infestation in buildings appears to have become more common with the general adoption of central heating plants. Heated basements favor a longer period of activity in each season. (See Figure 41.)

Subterranean termites live in colonies in the ground. Each colony is made up of three distinct castes, reproductives (commonly known as kings and queens), workers, and soldiers. The workers and soldiers are small soft-bodied insects, grayish-to-white in color and without wings (Figure 42). Soldiers differ from the workers only in having larger brownish heads and jaws. The unmated reproductives have small brown or black bodies with two pairs of long, whitish, opaque wings of equal size (Figure 43). Termites of this caste possess wings (shortly before and during their nuptial flight) of equal size and have a thick waist, in contrast to winged ants which have slender waists and hind wings that are much smaller than the front wings (Figure 44).

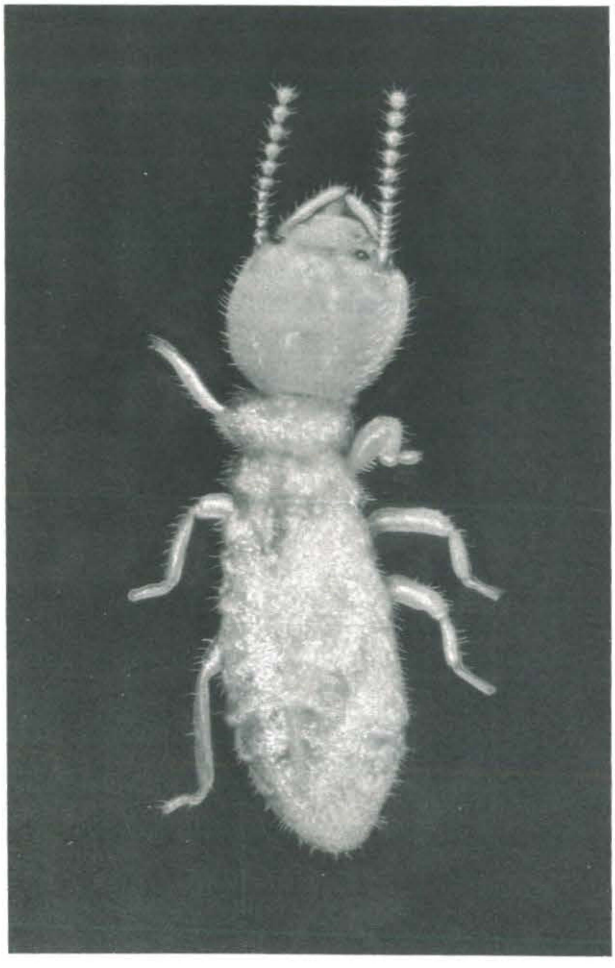


FIGURE 42

Subterranean Termite Worker

3. TYPES OF MATERIAL DAMAGED. The food of subterranean termites is cellulose obtained from wood, wood products, and other plant tissues. These termites are especially destructive to the woodwork of buildings, fence posts, telephone poles, and any other wood in contact with the ground or accessible to the termites from the ground, unless such wood has been appropriately treated to prevent their attack. Paper, wallboard, many fibers, and other cellulose-containing materials also are often damaged. Subterranean termites occasionally injure living plants.

FIGURE 43

Subterranean Termite Reproductive Before Wings Have Been Cast Off

4. HOW TO RECOGNIZE THE PRESENCE AND WORK OF SUBTERRANEAN TERMITES. The appearance and flight of large numbers of winged termite reproductives in a building may be the first indication of the presence of subterranean termites, and quantities of discarded

wings may be seen after each flight. (See Figure 45.) Flights occur most often after the first warm days of spring, but may take place almost any time during spring, summer, or fall. Termite damage to wood is often not evident externally because the workers and soldiers remain within their tunnels inside the wood.

To pass from their underground nest to wood not in direct contact with the soil, termites construct earth-like shelter tubes from the ground to the wood. These tubes range from ¼ to ½ inch or more in diameter, and are easily recognized (Figure 46). The tubes, however, may also be built in cracks between bricks or hollow tile, or crevices in poured concrete, and not be visible from outside. Signs of subterranean termite work may also be found at the ground level of grade stakes, form boards, tree stumps, wooden porches and steps, or any other wood having contact with the soil or within reach from the soil.

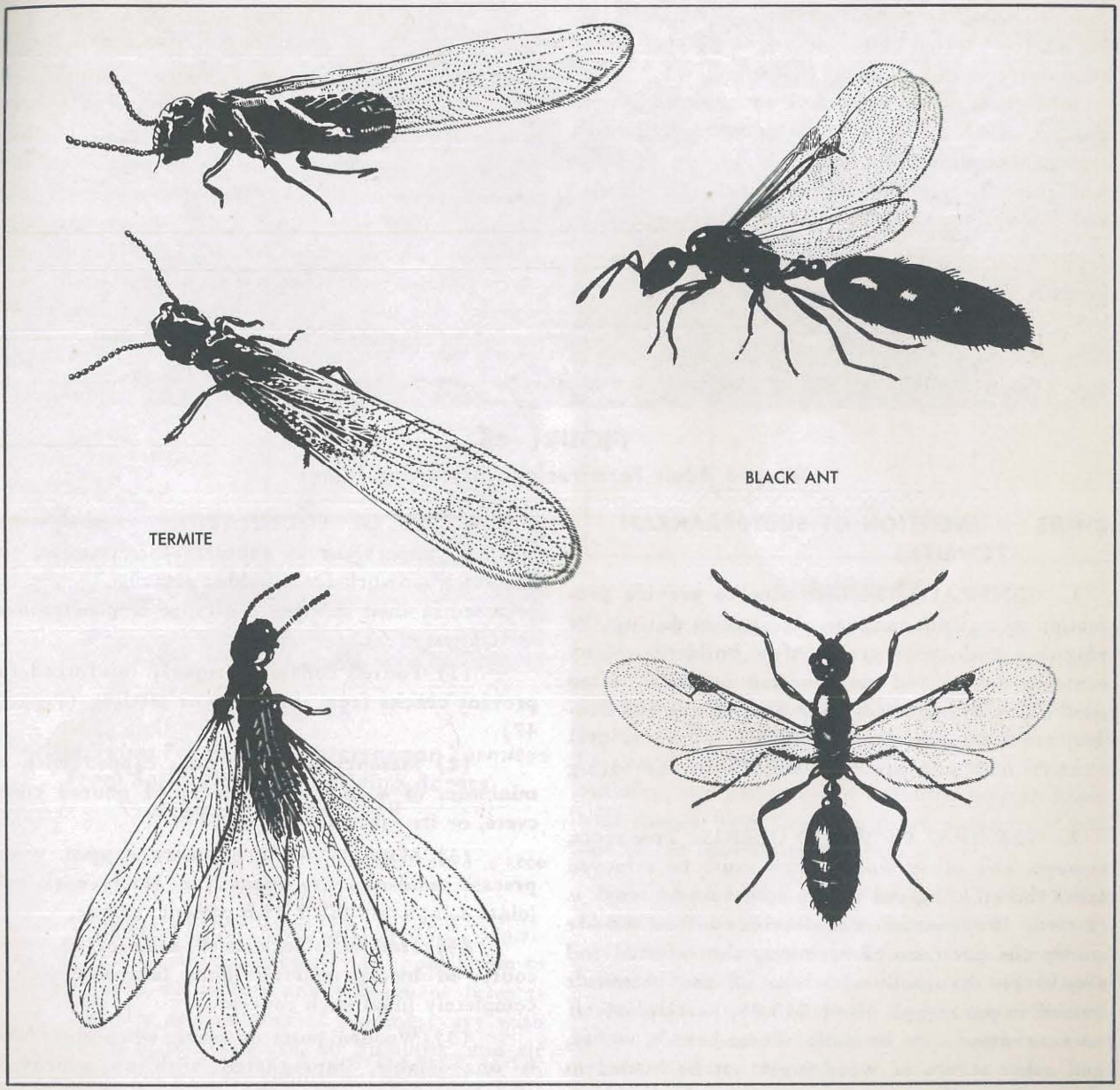


FIGURE 44

Comparison of Winged Termite and Winged Black Ant

FIGURE 45

Winged Adult Termites and Discarded Wings

B10.03 PREVENTION OF SUBTERRANEAN TERMITES

1. GENERAL. The best time to provide protection from subterranean termites is during the planning and construction of a building. Many common design and construction practices, often used either in ignorance or indifference to the danger, are favorable for infestation. (Termite-preventive measures are also helpful in combating wood decay.)

2. REMOVAL OF WOOD DEBRIS. Tree roots, stumps, and other wood debris must be removed from the building site before construction work is started. If examination of debris or soil on the site shows the presence of termites, the infested soil should be drenched with one of the chemicals named in paragraph 4b of B10.05, particularly if no excavation is to be made. Form boards, stakes, and other scraps of wood must not be buried in the earth or allowed to remain under the building. If no wood is on or in the soil, the danger of a large population of subterranean termites developing in the soil is distinctly reduced.

3. TYPES OF FOUNDATION. Foundations must be impervious to subterranean termites to protect woodwork from hidden attack. They may be rated in their relative resistance to penetration as follows:

(1) Poured concrete properly reinforced to prevent cracks from shrinkage or settling (Figure 47).

(2) Masonry walls or piers capped with a minimum of 4 inches of reinforced poured concrete, or its equivalent (Figure 48).

(3) Masonry walls or piers capped with precast solid-concrete blocks or brick with all joints completely filled with cement mortar.

(4) Hollow blocks with cells of the top course of blocks, and all joints between blocks, completely filled with concrete.

(5) Wooden posts or piers, when their use is unavoidable, impregnated with an approved chemical preservative (by a standard pressure process), capped with metal termite shields to prevent termites from gaining hidden access to the building itself.

FIGURE 46

Shelter Tubes Formed by Subterranean Termites From Soil to Wood of Building Across Poured Concrete Wall

(6) Heartwood of a naturally resistant tree (paragraph 11 of B10.03).

4. VENTILATION AND DRAINAGE. Openings in foundations are necessary for ventilation to prevent dead air spaces and subsequent infestation. The size and number of openings vary with the amount of soil moisture, air humidity, and air movement. For average conditions, openings should be not less than 1 square foot per 25 lineal feet of exterior wall. Shrubbery must be kept far enough from the foundation and ventilator openings to allow free circulation of air, and moisture must not be permitted to accumulate in soil beneath the building. For this purpose, the soil surface should be sloped to drain surface water away from the building, and basements of buildings on low or wet land should have drainage pipes around the outside of the foundation footings.

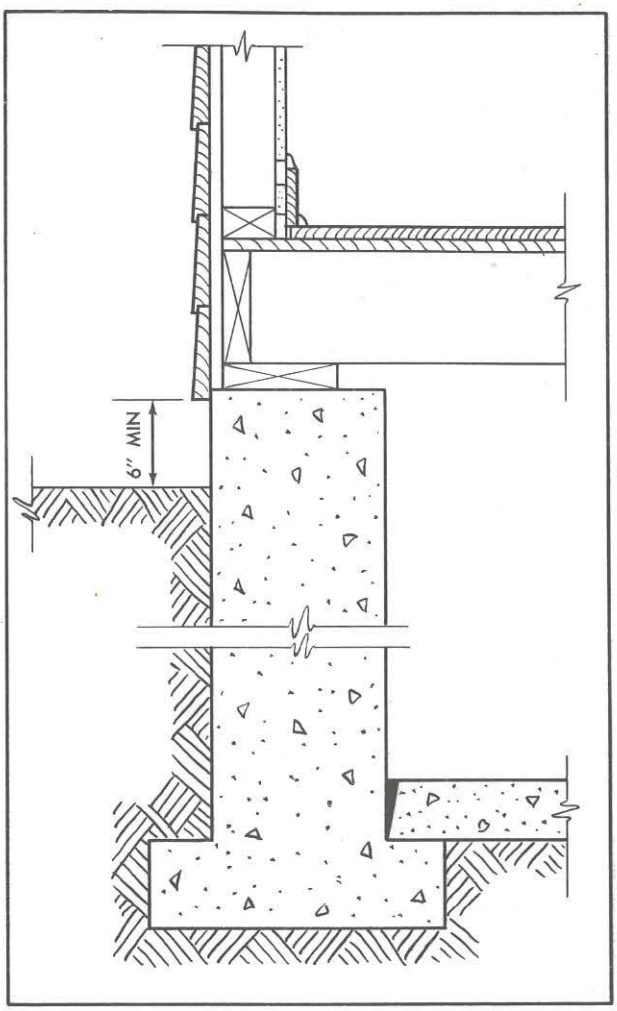


FIGURE 47

Poured Concrete Foundation Wall or Pier, Expansion Joint Filled With Coal-Tar Pitch

5. CLEARANCE BENEATH BUILDINGS. There must be a minimum clearance of 18 inches (30 inches in southern and more humid regions) beneath floors of wooden buildings for crawl space in which to make periodic inspections. Suitable openings through foundations, or elsewhere, must permit access to this space.

6. GRADE LINE AND SKIRTING CLEARANCE. The soil grade line must be maintained at least 6 inches below all exterior woodwork or, in the case of masonry superstructures, at least 6

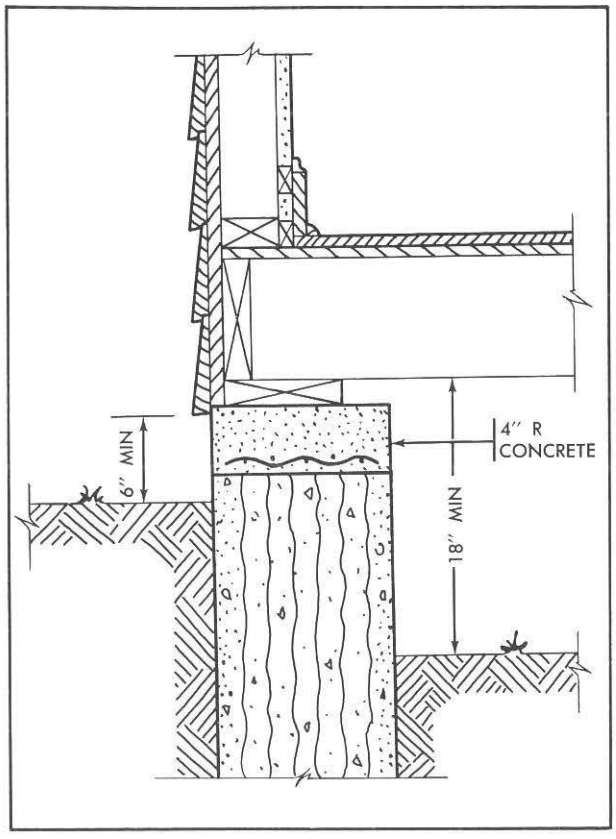


FIGURE 48

Reinforced Poured Concrete Cap on Masonry Wall or Pier

inches below the top of the foundation. For buildings with pier foundations and wooden skirtings or lattice, a clearance of from 3 to 6 inches between skirting and the ground is recommended during the season of termite activity so subterranean termites can not reach the wood (Figure 49). A 3-inch minimum clearance from piers should also be maintained. If winter weather is severe, both ventilation openings and skirting clearance from the ground are frequently closed to ensure floor warmth, usually by banking dirt up to the skirting. The minimum clearance should be re-established before termite activity begins the following spring.

7. PORCHES, STEPS, TERRACES, PLATFORMS. Parts of a building, such as porches, steps, terraces, and platforms, should be isolated from the main part of the building by properly designed metal shields or stops (Figure 50). Spaces beneath them should not be filled (Figure 51) and should be provided with an access door. Form boards should be removed from beneath concrete steps and similar construction. The lower, or outer, step of wooden porches and platform supports should rest on solid concrete bases extending at least 6 inches aboveground. (See Figure 52.) Door jambs or frames should not extend into basement or ground-floor concrete, and outside coal bins should be installed with a minimum, unbridged clearance of 2 inches from the building proper.

8. WOODEN FINISH OVER CONCRETE OR MASONRY. Pressure-treated wood should be used for sleepers, nailing strips, subflooring, and wall linings over concrete or masonry in basement or ground areas. Sleepers, studs, and furring strips must not be imbedded in concrete.

9. PIPES AND CONDUITS. All plumbing, electrical conduits, and other piping should be clear of the ground and unsupported by wood that touches the ground. Piping that penetrates walls or floors below ground should be provided with a funnel type of shield thoroughly calked with a coal-tar mastic.

10. EXPANSION JOINTS. Expansion and construction joints in floors and walls, and joints between the foundation wall and floor slabs at or below ground level in wooden structures should be sealed with either coal-tar pitch or a coal-tar plastic cement and crimped metal connectors. Joints in exposed floor slabs should not lie directly beneath wooden partitions because failure in the seal may permit termites to penetrate the partitions.

11. NATURALLY RESISTANT WOOD. No untreated wood is completely immune to attack by subterranean termites, but the heartwood of certain trees is relatively resistant. Sapwood is not resistant and should be removed from timbers that must be used in contact with the ground without receiving chemical treatment. Resistant woods available commercially are California redwood, pitchy or fat longleaf yellow pine, and all-heart southern tidewater red cypress. Eastern red cedar is fairly resistant and certain other woods available in tropical regions are known to be comparatively resistant to termites.

12. CHEMICAL TREATMENT OF WOOD. Wooden members that must be used in contact with or near the ground should be pressure-treated with a chemical preservative by an approved process (Federal Specification T-T-W-571b).

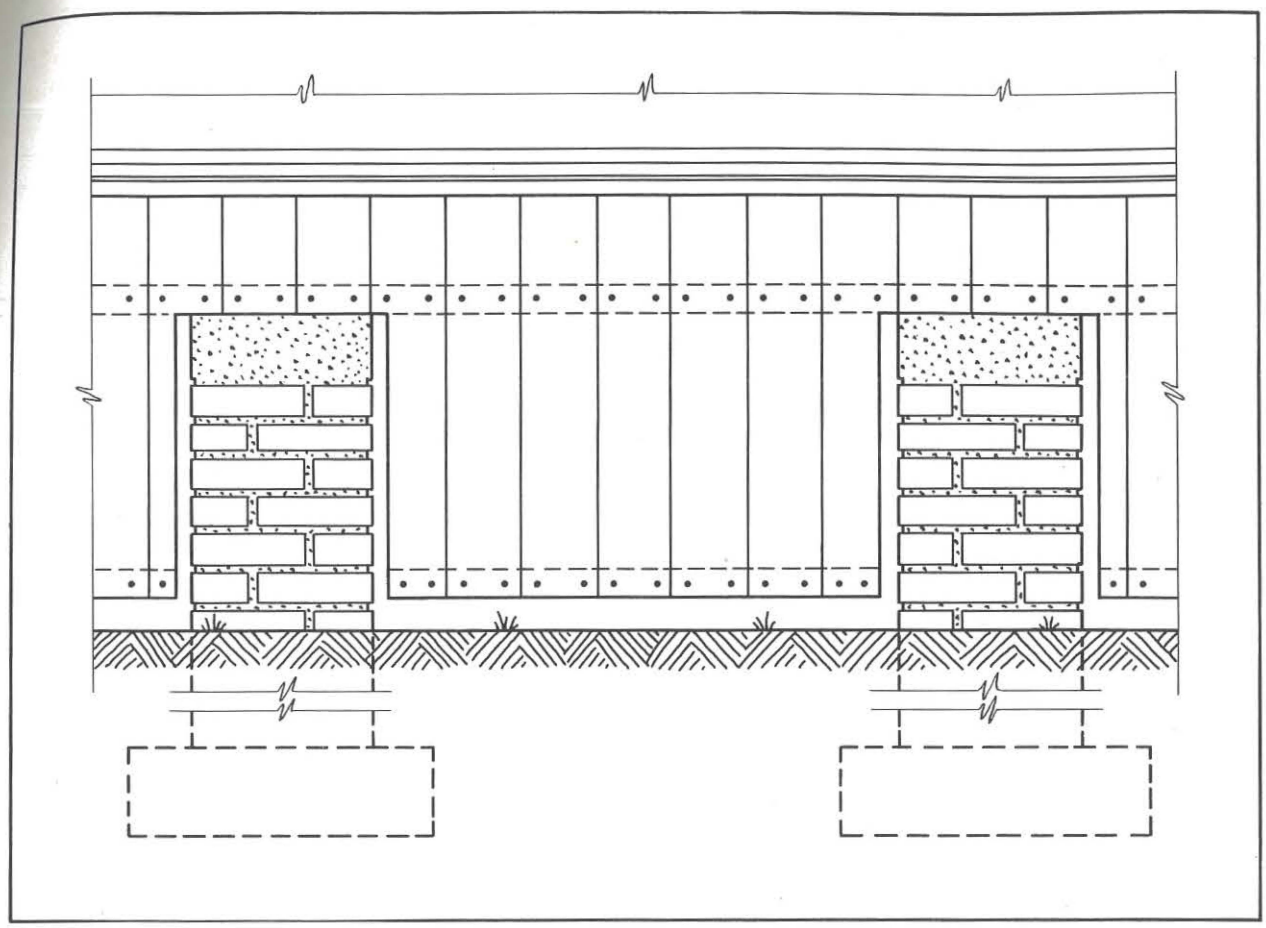


FIGURE 49

Wooden Skirting With Clearance

13. METAL TERMITE SHIELDS. Shields of corrosion-resisting metal, when required, must be installed, and even then they are only supplemental to good construction as a means of control of subterranean termites (Figures 53 to 55). Many features of building design obviate the need for termite shields. Installation of metal termite shields should be made at the time of construction or when extensive repairs are required, and then under specific directions from the entomologist at headquarters. Metal shields already in place must be maintained properly to be of value. Joints and angles must not be broken, and shields must not be bent or damaged in any way. Shields do not preclude the need for thorough periodic inspections.

B10.04 PERIODIC INSPECTIONS

All structures built wholly or in part of wood must be inspected annually for termite infestations, regardless of preventive measures employed in construction (paragraph B10.03). If termites are found, prompt steps must be taken to determine the seriousness of the situation and to control the infestation.

B10.05 CONTROL OF ESTABLISHED INFESTATIONS

1. GENERAL. When a termite infestation is discovered in a building, it must be examined to determine its extent. A localized infestation will respond immediately to relatively simple control methods. If the infestation is extensive and involves serious structural damage, the advice of the entomologist at higher headquarters should be secured. The same principles are observed in controlling subterranean termite infestations in existing buildings as are used to prevent termite damage when new buildings are constructed.

2. SANITATION MEASURES.

a. Form Boards. Remove all old form boards

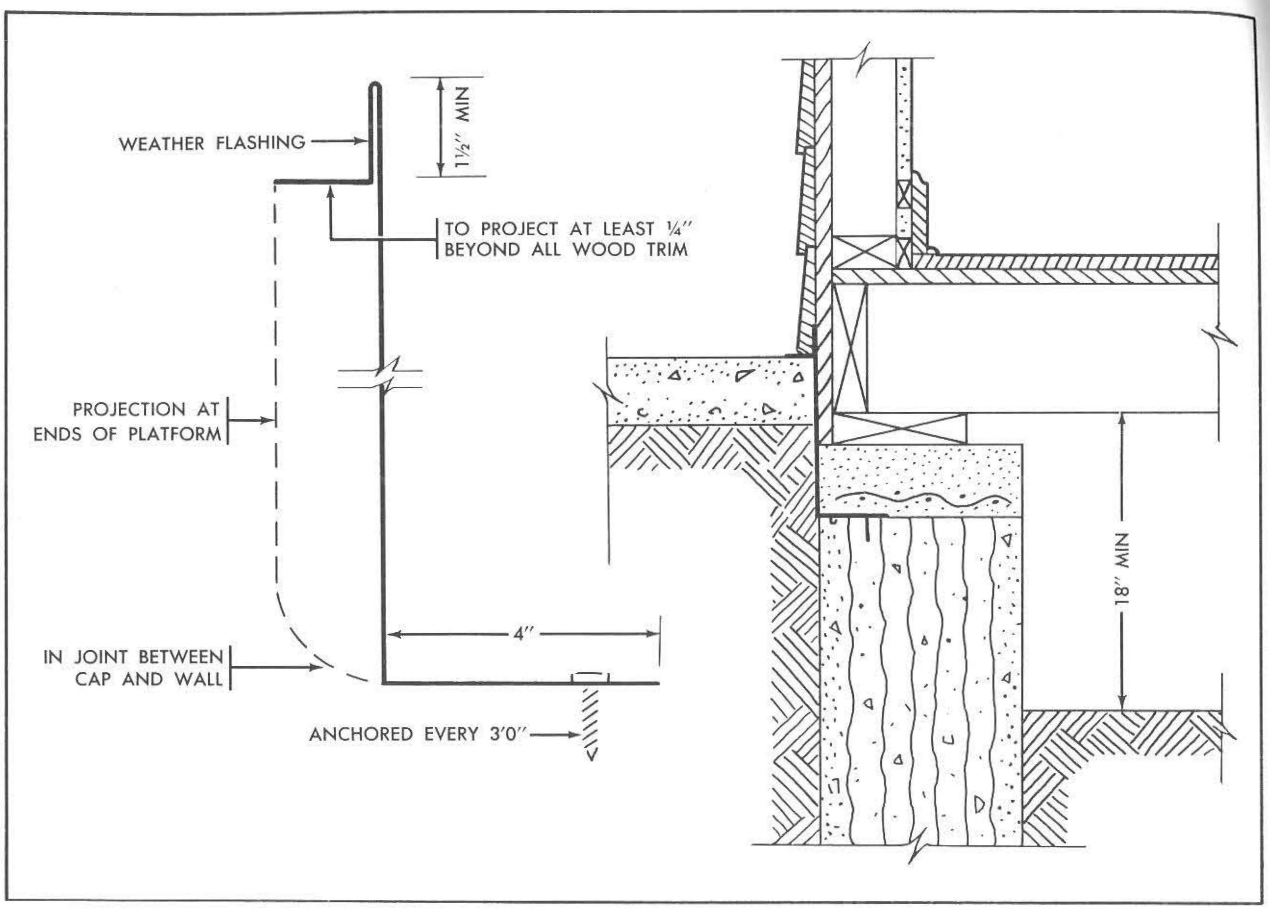


FIGURE 50

Installation of Metal Shield or Apron To Protect From Hidden Attack by Subterranean Termites on Porches, Steps, and Terraces (Note: Shield Projects at Top and Ends of Porch Slab)

and other wood debris from the soil beneath or near the building.

b. Contact. Break contact of wood with the soil by destroying shelter tubes. Keep the contact broken.

3. STRUCTURAL CHANGES. To block off subterranean termites from the building, all woodwork should be isolated from the ground and unexcavated areas under the building properly ventilated. Wooden members, such as steps and ladders, that are in contact with the ground, should be separated from the building at the first opportunity and set on poured-concrete bases. Cracks or expansion joints in concrete or masonry under wood must be filled with cement grout, coal-tar pitch, or coal-tar plastic cement. Under certain conditions, metal shields may be added if recommended and supervised by the entomologist at higher headquarters. (See Figure 56.)

4. CHEMICAL SOIL BARRIERS.

a. General. To assure complete blocking of subterranean termites from woodwork of the building, dig a trench around the foundation walls and piers, where shelter tubes or other evidence has been found, and apply (under competent and trained supervision) an approved chemical.

b. Chemicals. The following poisons are effective for treating trench barriers. (Diesel oil may be substituted for the No. 2 fuel oil.) The dosage given is for every 10 lineal feet of trench if footings are shallow; for deep footings, the dosage should be doubled:

(1) Sodium arsenite: 10-percent solution in water; dosage, 2 gallons.

(2) Trichlorobenzene: 1 part by volume to 3 parts of No. 2 fuel oil; dosage, 2 gallons.

(3) DDT: 5-percent solution in No. 2 fuel oil; dosage, 4 gallons.

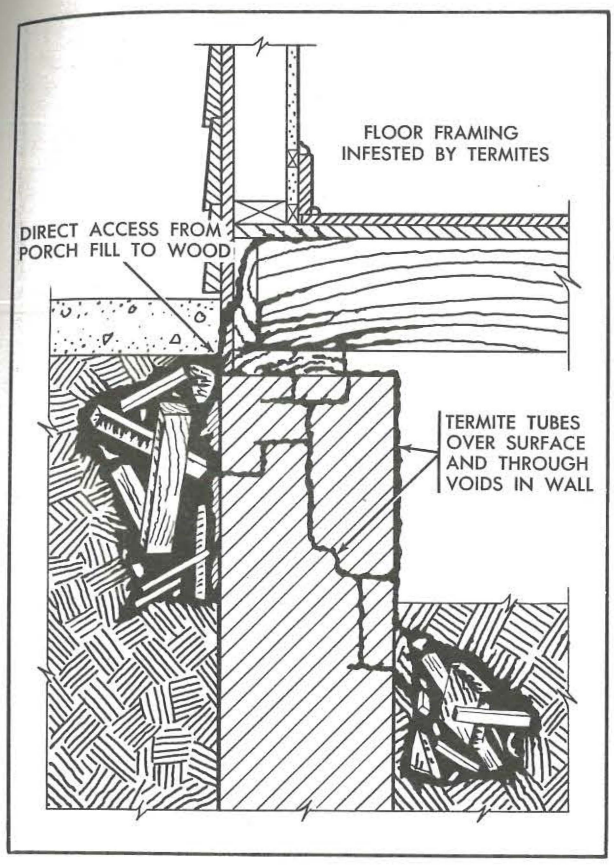


FIGURE 51

Subterranean Termites Infesting Building From Pieces of Wood in Soil or in Dirt Fill Under Porch

(4) Pentachlorophenol: 5-percent solution in No. 2 fuel oil; dosage, 5 gallons.

(5) Coal-tar creosote: 1 part by volume to 2 parts of No. 2 fuel oil; dosage, 6 gallons.

c. Method of Application. Dig a trench the width of a shovel around piers, continuous foundation walls, and vertical pipes. A trench from 12 to 15 inches deep is adequate if foundations have shallow footings and no voids or cracks. A trench at least 30 inches deep is necessary along basement walls or when the foundation has developed cracks. In no case should the trench extend below the top of the foundation footing.

When footings are shallow, pour part of the dosage of chemical into the bottom of the trench and the rest on top of the replaced soil. (Under buildings and porches it may be desirable not to refill the trench.) When footings are deep, pour part of the chemical into the bottom of the trench, replace about 6 inches of soil and make a second application. Repeat this process to provide an even distribution of chemical from the bottom to the top of the trench.

Under some soil conditions, when a trench 30 inches deep is impractical, 1-inch auger or rod holes a foot apart extending to the footing may be bored in the bottom of a 12- to 15-inch trench. Half the dosage of poison should be poured into the holes and the remainder mixed with the soil in the trench.

If the location of an abutting ground slab prevents trenching along a wall, a strip of the slab may need to be removed and repaired later. In some cases it may be desirable to bore holes through the slab into the ground, about 18 inches apart, near the foundation wall. Pour the chemical through the holes in the concrete and plug the holes. To force the soil poison into locations hard to reach, a treatment wand (Figure 57) is sometimes helpful.

Ornamental plantings should be protected from injury by the soil poisons by lining the trench next to their roots with tar paper or other heavy paper. Where applications must be made close to the base of shrubbery, chlordane diluted at the rate of 1 ounce of 50-percent wettable powder to a gallon of water should be sprayed liberally so as to soak the ground in those areas.

B10.06 NONSUBTERRANEAN TERMITES

1. GENERAL. Termites usually receive their common name from the location of their colony or nest; therefore those that colonize aboveground, whether they be of the dry-wood, damp-wood, or rotten-wood variety, are called nonsubterranean. Although they all have the common habit of feeding on cellulose usually derived from wood or wood products, their life cycles and methods of attack, and consequently methods of control, are quite different.

Of the several kinds of nonsubterranean termites, those causing most damage to Navy installations are the common dry-wood termites (*Kalotermes* species) and the so-called powder-post termites (*Cryptotermes* species). These insects attack sound, dry wood in structures, utility poles, and supplies, including stored lumber and furnishings. Further, they attack other products containing cellulose, such as paper, books, fiberboard, and insulating materials. Figure 41 shows the northern United States boundaries of dry-wood termites.

The colonies live in a series of interconnected chambers within the wood in which they work,

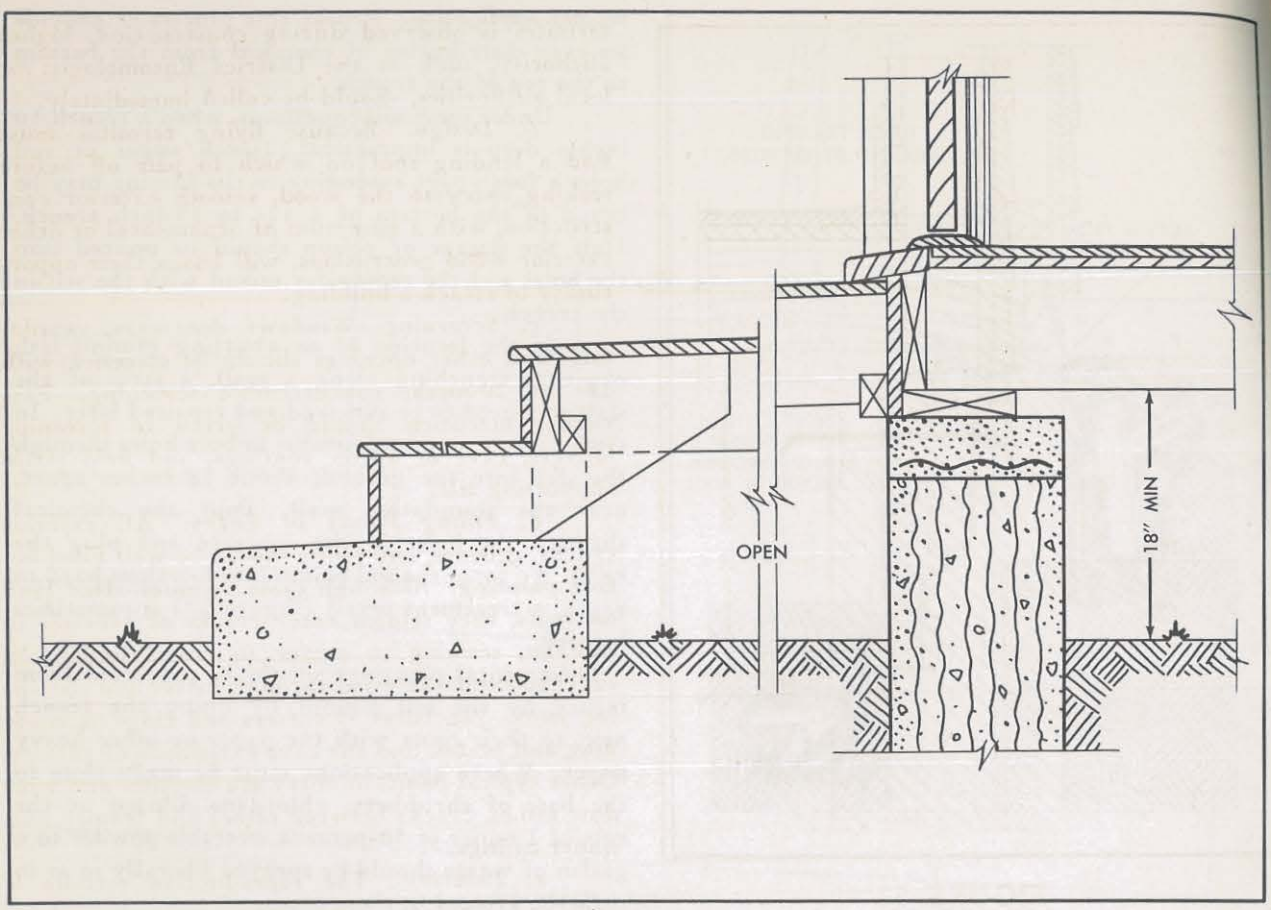


FIGURE 52

Wooden Steps of Porch Protected by Resting Carriage on Poured Concrete

with the grain and cross grain, and do not necessarily follow the seasonal rings of spring growth as do the subterranean termites. Except for the release of the winged reproductives, their entire life cycle is confined to the wood. Other species of the nonsubterranean termite attack damp wood or rotten wood, but they are of limited economic importance in stateside shore stations.

2. LOCATING AND IDENTIFYING INFESTATIONS. In areas where dry-wood or powder-post termites are known to exist, periodic inspections should be made of all portions of structures, including the attic and substructural areas. When a flight of reproductives is observed, it is often possible to trace it to its source. This is important because the release of winged reproductives indicates the existence of a large colony; it is usually the fourth year before the first reproductives are released. The entire colony is not confined to a single chamber but is distributed throughout the wood in interconnected galleries. The nymphs keep the galleries clean and permit no pellets of excreta (Figure 58), or other dirt, to remain in feeding areas. They either place the pellets in unused chambers or cast them outside through small openings called kick-out holes. Location of a pile of these pellets (Figure 58) readily indicates a colony. If the pellets are confined to a small area or stack, it is evident that the kick-out hole is nearby, and search with a good light will show it. (The hole is usually sealed over with a brown excretion resembling varnish.) Scattered or broad distribution of pellets indicates that they have dropped some distance, so the search for the kick-out hole will be governed accordingly.

Another method of locating damage is to prod the wood with a knife blade, ice pick, or some other tool that will penetrate the surface and ex-

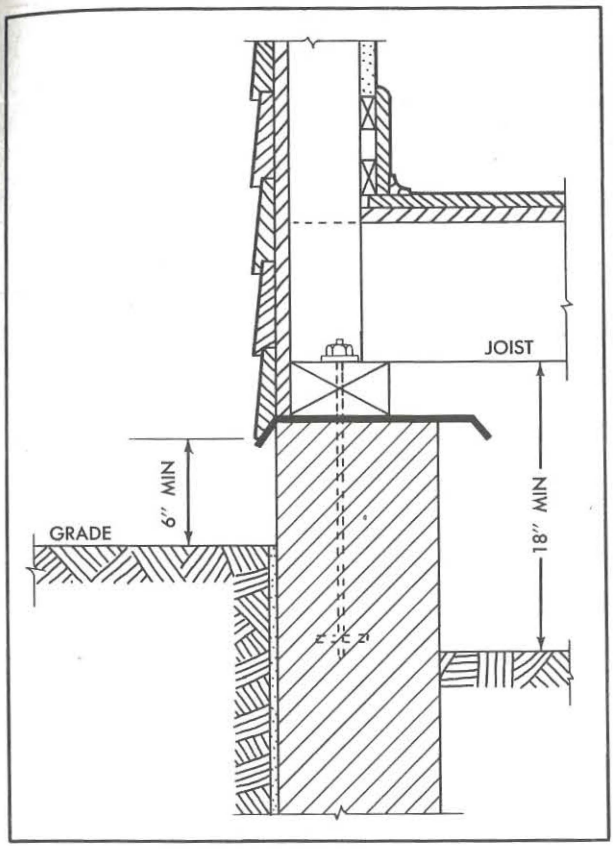


FIGURE 53

Bread-Pan Shield Over Foundation Wall

pose the hollow galleries beneath. Infested wood may also be detected by tapping. The wood will give either a hollow sound or a rustle if the termite tunnels are just beneath the surface.

3. DETERRENT CONSTRUCTION. The dry-wood termite being a localized problem, national building codes and general termite specifications have stressed operations to prevent infestation by subterranean termites, but have offered little or nothing for the prevention of attacks by dry-wood termites. Except for cases in which they are built into a structure, by use of infested lumber, they make their invasion on the wing. (This is in marked contrast to subterranean termites that enter buildings almost entirely from the earth via exploration tunnels.) The following methods should contribute considerably toward their prevention.

a. Lumber. All lumber used for construction should be carefully inspected for evidence of infestation and, if infested, should be burned, pressure-treated, or dip-treated. If a flight of termites is observed during construction, higher authority, such as the District Entomologist or local authorities, should be called immediately.

b. Design. Because flying termites must find a landing spot on which to pair off before seeking entry to the wood, smooth exterior construction, with a minimum of ornamental or other exterior wood protrusions, will lessen their opportunity to attack a building.

c. Screening. Windows, doorways, ventilators, and other openings should be screened with 18- or 20-mesh, noncorrodible screening. Particular attention should be given to screening louvers, eave or apron ventings, and field strips supporting tile.

d. Filling Points of Entry. All exterior cracks, grooves, and joints should be well filled before painting. Although these termites often land on roofs, they seldom enter cracks or crevices in shingles, seeming to prefer to crawl under the eaves to enter the wood through rafter and sheathing joints, junctures of rafters and ridge or studding and plates, and the eave extensions of rafters. Other typical points of entry are mortises and window sashes, cracks between sashes and frames, and under casings.

e. Painting. The reproductive termite is very vulnerable to insectivorous animals such as ants, spiders, and birds, and any means used to delay his entrance into the wood will cut down on the number of successful invasions. A good coat of paint, with careful application at points of vulnerability, will aid in warding off attack.

f. Treated Lumber. The use of chemically treated wood is often suggested as a permanent cure for dry-wood termites, but unless the entire structure is treated, the prevention is questionable. The insects will by-pass treated members to attack untreated members, furnishings, and supplies. In locations of heavy local population or unusual exposure, lumber treated according to Federal Specification TT-W-571c, Table II or Table III, might well be justified.

4. CONTROL. Immediate control of an infestation of nonsubterranean termites is imperative. Infestations often are not located until a colony has done considerable damage and matured to the stage of releasing reproductives for new colonies. The following control methods are recommended.

a. Replacement. If an infestation is limited and infested members are exposed, remove, burn, and replace the infested wood. Be careful, however, to remove all the infested wood because

FIGURE 54

Metal Termite Shields in Place on Foundation Piers

termites travel from one chamber to the next through holes often less than ⅛ inch in diameter.

b. Drill Treatment. The drill treatment makes use of termites' biological habits of grooming, or licking and cleansing, one another.

Drill $\frac{3}{16}$-inch holes into the runways, through the kick-out holes, fill them with insecticide (with a dust gun or powder puffer), and close the holes with putty or dowling. As they travel through the runways, termites pick up the insecticide on their body hairs and later ingest it as a stomach poison during grooming.

Materials commonly used for this treatment are finely ground or micronized arsenical dust (arsenic trioxide) mixed with lightweight dusting talc or diatomaceous earth. Paris green may also be used because it can be extended and made lighter by diluting it with an equal amount of talc or cornstarch. Experiments with chlorinated hydrocarbons, such as 5 percent DDT, 2 percent chlordane, and 0.3 percent lindane in dust form, have also been successful.

Liquids containing ethylene dibromide, orthodichlorobenzene, and pentachlorophenol with added lindane or chlordane are also being endorsed for fumigating localized colonies.

c. Fumigation for Dry-Wood Termites. During the past few years an entirely new procedure has been developed for controlling dry-wood termites, especially when infestations are scattered or in inaccessible sections of the building. Fumigation is often quicker and less costly than poison dust or liquids and will, of course, kill all other pest insects, such as clothes moths, silverfish, and cockroaches, in the structure. It does not, however, prevent termites from reinfesting because no poisonous residue is left in the galleries.

WARNING

Fumigation with toxic gases is a very dangerous procedure for operating personnel, and unless the characteristics of the gas are thoroughly understood, aeration following fumigation may leave a toxic residue hazardous to later occupants.

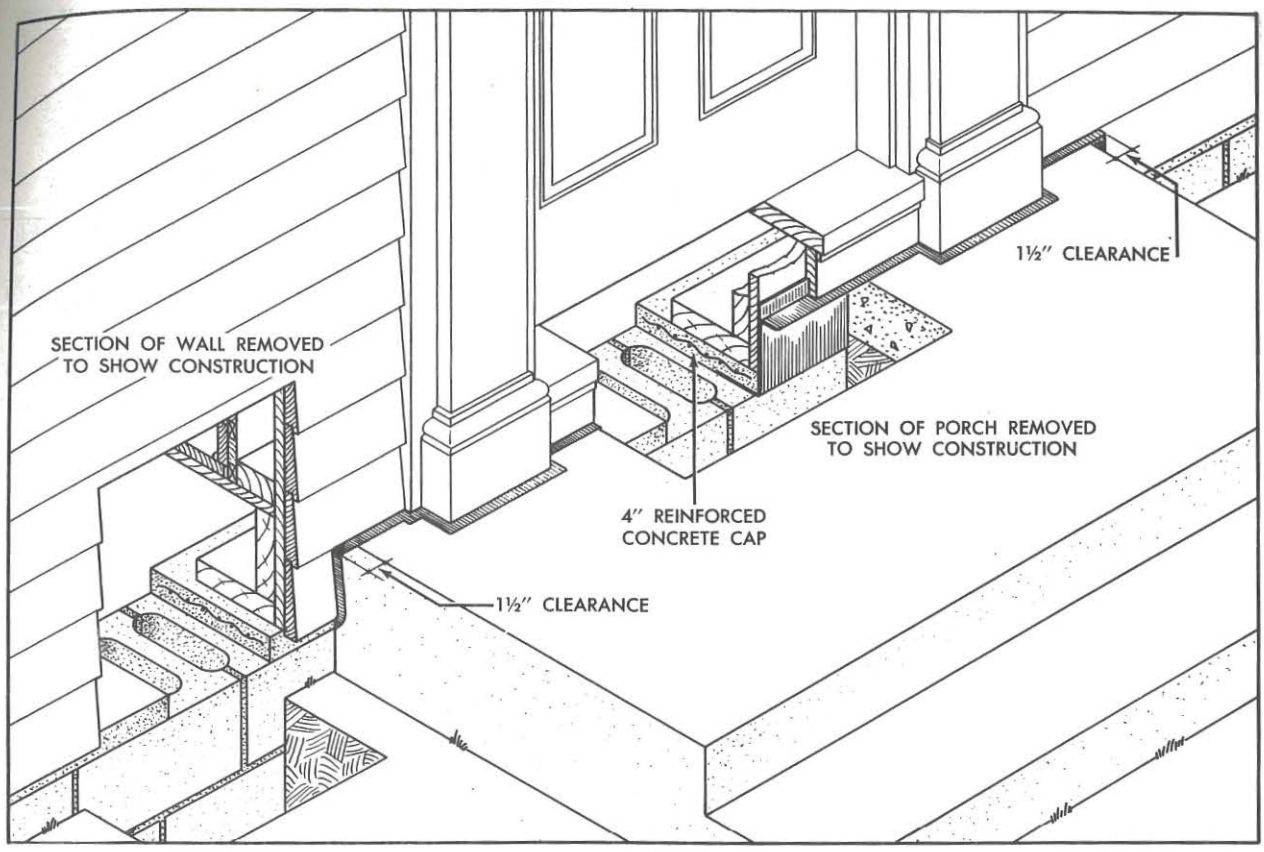


FIGURE 55

Metal Apron Inserted Between Concrete Slab and Woodwork

Fumigation must be personally supervised by a District Public Works Entomologist. If there is no entomologist, specifications must be cleared through the Bureau of Yards and Docks (Code C-348) prior to fumigation.

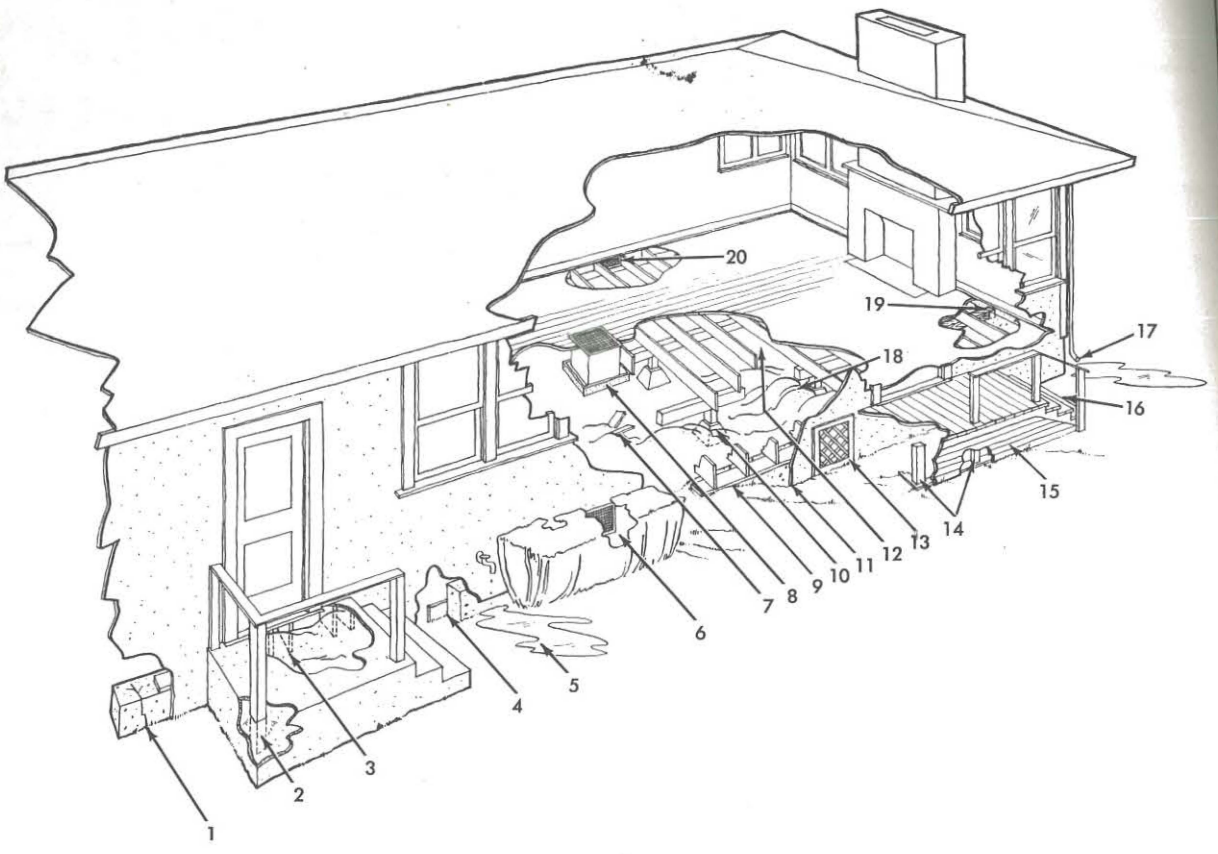
Successful fumigation requires exterior sealing of a structure to the extent that the entire building becomes a fumigation vault.

The selection of the method of sealing, one of the major expenses of the operation, determines the procedure to be followed. Sealing windows, doors, ventilators, and other means of gas escape often suffices for stucco or masonry structures of tight construction. Loosely constructed wooden buildings, however, must be entirely covered with a gas-impervious membrane, such as a rubberized fabric tarpaulin or three-ply, impregnated or glazed Kraft paper. The fumigant is released throughout the building after it has been sealed. Most operators use methyl bromide because of the flammability and explosiveness of other fumigants.

The entire structure is measured to determine the gross cubic content including attic and substructural area, and the dosage of methyl bromide is figured at 2.5 to 3.5 pounds of gas per 1,000 cubic feet of space. The larger dosage is used on small structures and those in which the thoroughness of the seal is questionable.

Fumigation should never be attempted unless the temperature is above 60 F, to facilitate rapid gas diffusion, or when night temperatures may drop below 40 F. All plants and pets, including fish, will be killed if not removed from the area to be gassed. Methyl bromide gas has a tendency to react to certain materials, causing a bad and continuing odor; these materials, such as reclaimed rubber, furs, foam rubber mattresses or pillows, unsealed greases including face creams, iodized salt, suede shoes, and silver polish papers or creams, should also be removed.

d. Temperature Control. Dry-wood or powder-post termites infesting furniture or other portable materials are, on occasion, killed by placing the infested objects in a chamber that is heated



1. CRACKS IN FOUNDATION PERMIT HIDDEN POINTS OF ENTRY FROM SOIL TO SILL.

2. POSTS THROUGH CONCRETE IN CONTACT WITH SUBSTRUCTURAL SOIL. WATCH DOOR FRAMES AND INTERMEDIATE SUPPORTING POSTS.

3. WOOD FRAMING MEMBERS IN CONTACT WITH EARTHFILL UNDER CONCRETE SLAB.

4. FORM BOARDS LEFT IN PLACE CONTRIBUTE TO TERMITE FOOD SUPPLY.

5. LEAKING PIPES AND DRIPPING FAUCETS SUSTAIN SOIL MOISTURE. EXCESS IRRIGATION HAS SAME EFFECT.

6. SHRUBBERY BLOCKING AIR FLOW THROUGH VENTS.

7. DEBRIS SUPPORTS TERMITE COLONY UNTIL LARGE POPULATION ATTACKS SUPERSTRUCTURE.

8. HEATING UNIT ACCELERATES TERMITE DEVELOPMENT BY MAINTAINING WARMTH OF COLONY ON A YEAR-ROUND BASIS.

9. FOUNDATION WALL TOO LOW PERMITS WOOD TO CONTACT SOIL. ADDING TOP SOIL OFTEN BUILDS EXTERIOR GRADE UP TO SILL LEVEL.

10. FOOTING TOO LOW OR SOIL THROWN AGAINST IT CAUSES WOOD-SOIL CONTACT. THERE SHOULD BE 8 INCHES OF CLEAN CONCRETE BETWEEN SOIL AND PIER BLOCK.

11. STUCCO CARRIED DOWN OVER CONCRETE FOUNDATION PERMITS HIDDEN ENTRANCE BETWEEN STUCCO AND FOUNDATION IF BOND FAILS.

12. INSUFFICIENT CLEARANCE FOR INSPECTION ALSO PERMITS EASY CONSTRUCTION OF TERMITE SHELTER TUBES FROM SOIL TO WOOD.

13. WOOD FRAMING OF CRAWL HOLE FORMING WOOD-SOIL CONTACT.

14. MUD SILL AND/OR POSTS IN CONTACT WITH SOIL.

15. WOOD SIDING AND SKIRTING FORM SOIL CONTACT. SHOULD BE A MINIMUM OF 3 INCHES CLEARANCE BETWEEN SKIRTING AND SOIL.

16. PORCH STEPS IN CONTACT WITH SOIL. ALSO WATCH FOR LADDERS AND OTHER WOODEN APPURTENANCES.

17. DOWNSPOUTS SHOULD CARRY WATER AWAY FROM BUILDING.

18. IMPROPER MAINTENANCE OF SOIL PILED AGAINST PIER FOOTING. ALSO MAKES CAREFUL INSPECTION IMPOSSIBLE.

19. WOOD GIRDER ENTERING RECESS AND FOUNDATION WALL. SHOULD HAVE 1 INCH FREE AIR SPACE ON BOTH SIDES AND END AND BE PROTECTED WITH A MOISTURE IMPERVIOUS SEAL.

20. VENTS PLACED BETWEEN JOISTS TUNNEL AIR THROUGH SPACE WITHOUT PROVIDING GOOD SUBSTRUCTURAL AERATION. VENTS PLACED IN FOUNDATION WALL GIVE BETTER AIR CIRCULATION.

FIGURE 56

Common Methods of Construction and Maintenance Which Encourage Subterranean Termite Attack

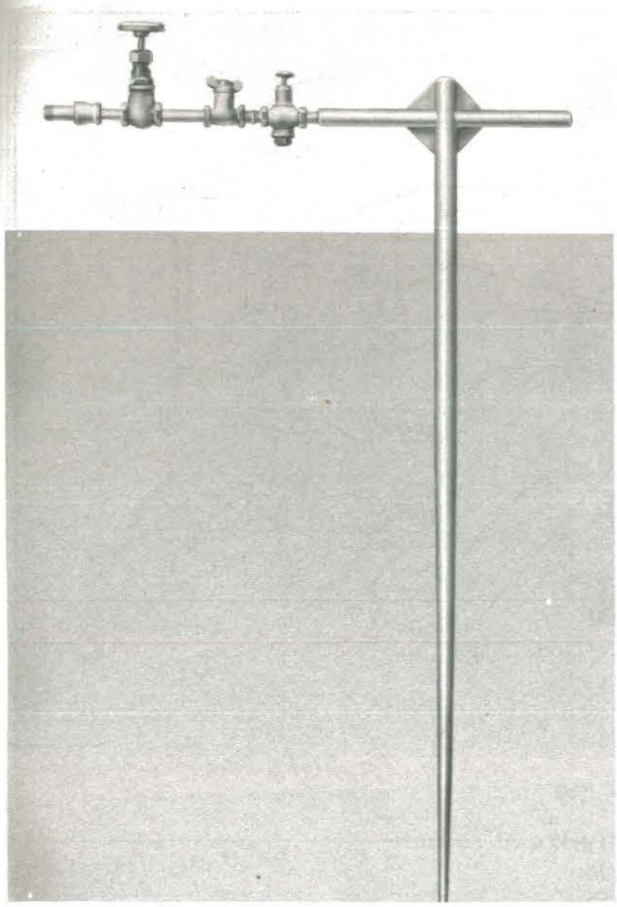


FIGURE 57

Termite Treatment Wand

FIGURE 58

Dry-Wood Termite Pellets

to a temperature of 150 F for 1½ hours, or 140 F for 4 hours. Such material may also be placed in refrigeration vaults and exposed to a temperature of 15 F for 4 days. Either of these methods will kill the termites and sterilize the eggs.

e. Area Survey. During or following a project for control of nonsubterranean termites, it is important to make an area survey to determine whether dead branches of trees, utility poles, or other outlying infestable materials are harboring a colony that may reinfest a treated structure.

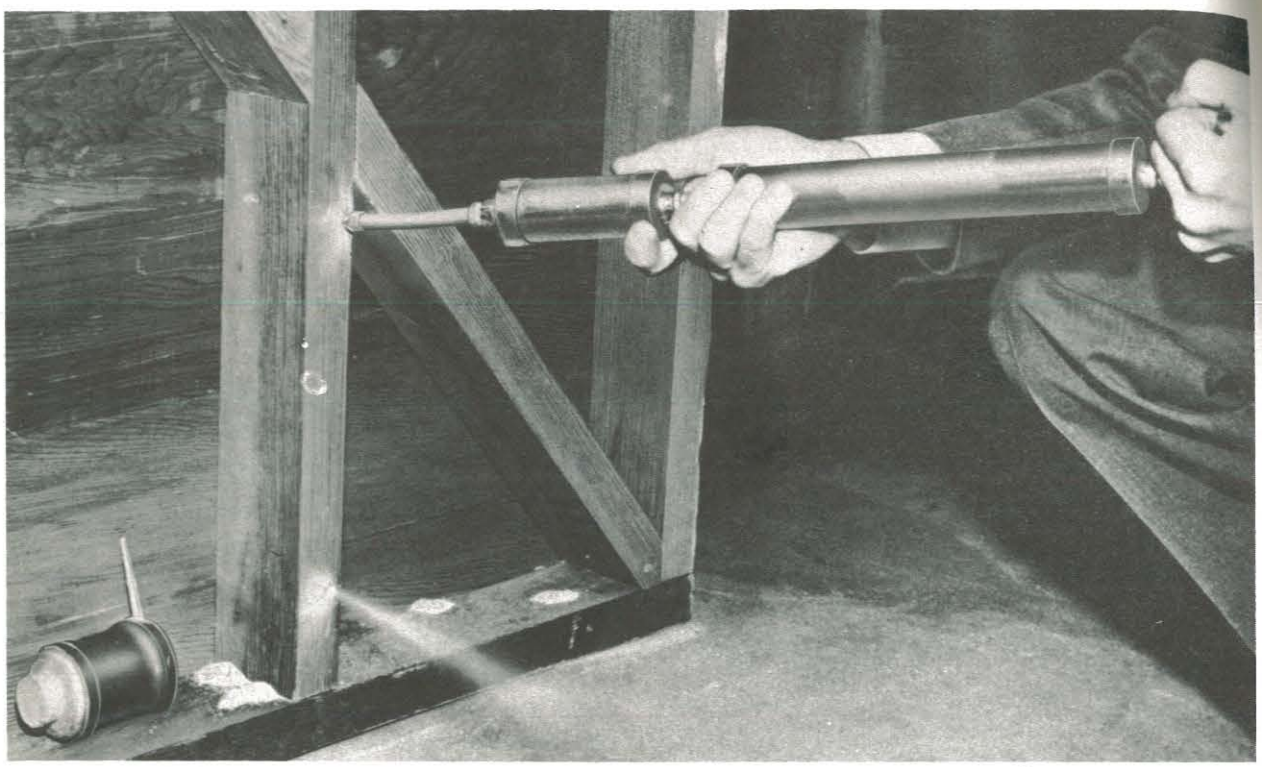


FIGURE 59

Dust Treatment for Dry-Wood Termite Infestation

Section 11. STORED-PRODUCT INSECTS

B11.01 SUSCEPTIBLE PRODUCTS

Many kinds of insect, including many small beetles and moths, attack subsistence supplies such as grains, meal, flour, breakfast cereals, rice, peas, beans, cured meats, cheese, dried dairy and poultry products, shelled nuts, and dried fruits. Although considerable food may actually be consumed, the greatest loss is from contamination. Woolen fabrics, hair, fur, and feathers are damaged by clothes moths and carpet beetles, and nylon and some other nonanimal fibers are sometimes, although infrequently, injured.

B11.02 FOOD PRODUCTS

1. GENERAL. Foodstuffs vary in their attraction for insects. Cereal grains, ground cereals, and ground seed products, except those containing free oil, and dried dairy, poultry and meat products generally favor the breeding of large numbers of insects. Sugars and starches are examples of purified foodstuffs that will not alone support insect development.

2. FOOD-INFESTING INSECTS.

(1) Certain active insects, especially cockroaches and ants, travel widely from one kind of food to another, thus contaminating foodstuffs that do not suffer infestation by insects with more restricted feeding habits. Clean, dry whole grains and seeds (including beans and peas) are generally infested only by insects such as grain and bean weevils that develop within the seed and whose presence may not be apparent until the weevils become adult and emerge. Fumigation with suitable chemicals (paragraph 3 of B11.08) will assure freedom from further development unless opportunity is given for reinfestation. Supplies of grains and seeds containing many broken kernels and chaff, or excessive moisture, are liable to attack and spoilage by many kinds of insects having external feeding habits; hence such supplies should be cleaned and dried if they are to be stored more than a few days.

(2) Several kinds of small, reddish-brown flour beetles and small meal moths infest cereals

and similar products high in carbohydrate content. Both the adult beetles and their pale, maggot-like larvae feed on the product. The moths themselves do not feed, but lay their eggs there, from which small caterpillars, characterized by the silk webbing which they spin, develop.

(3) Certain high-protein foods are attacked by a variety of insects. Carpet beetles and related species infest powdered foods, such as powdered whole egg, milk powder, and wheat-germ meal. Cured meats, such as ham and bacon, are attacked by larger (about ¼ inch) dark-colored larder, hide, and red-legged ham beetles. Cheese is commonly attacked by the maggots of a fly known as the cheese skipper, also by tiny cheese mites.

B11.03 FIBER PRODUCTS (ANIMAL)

Supplies made of wool, mohair, fur, hair, or animal bristles are liable to attack by clothes moths (Figure 60) and carpet beetles. Items subject to attack include woolen uniforms and blankets, wool- and fur-lined helmets, boots and gloves, and animal-fiber brushes, carpets, and furniture upholstering.

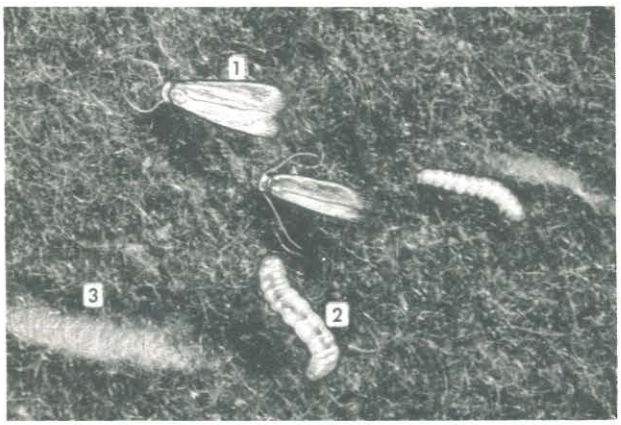


FIGURE 60

Webbing Clothes Moths on Woolen Blanket: 1, Adult; 2, Larvae; 3, Silken Webbing

B11.04 WOOD PRODUCTS

Besides termites (Section 10), powder-post beetles damage stored lumber and wood products, and wooden buildings (Figure 61). Hard woods, such as ash, oak, walnut, pecan, and hickory, with relatively large pores are most affected, and the sapwood is much more susceptible than the heartwood. Storage stock of items such as gun stocks, implement handles, wooden wheels, furniture, filing cabinets, and flooring may also be damaged. Varnished, shellacked, and painted wood surfaces are not attacked. Exit holes may appear, however, in such surfaces if the wood is infested prior to being finished.

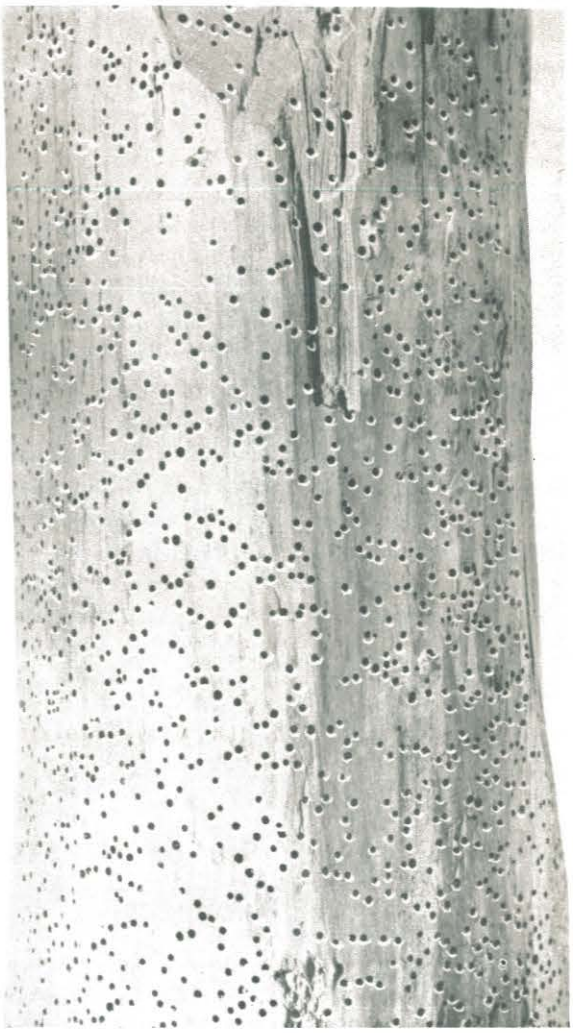


FIGURE 61

Damage by Powder-Post Beetles

B11.05 BOOKS AND PAPER RECORDS

The glue of book bindings and record labels, and the starch sizing of book paper, record cards, and labels (including bottle labels) are attractive to cockroaches (Section 8) and silverfish (Figure 62), and labels on files and shelves may be obliterated by their feeding. Damage is probably most severe in damp basements used for storage.

B11.06 MAINTENANCE OF INSECT-FREE STOCKS

1. GENERAL. Protective measures for subsistence supplies and other stocks susceptible to insect damage include purchase of insect-free products in quantities sufficient for only a reasonable

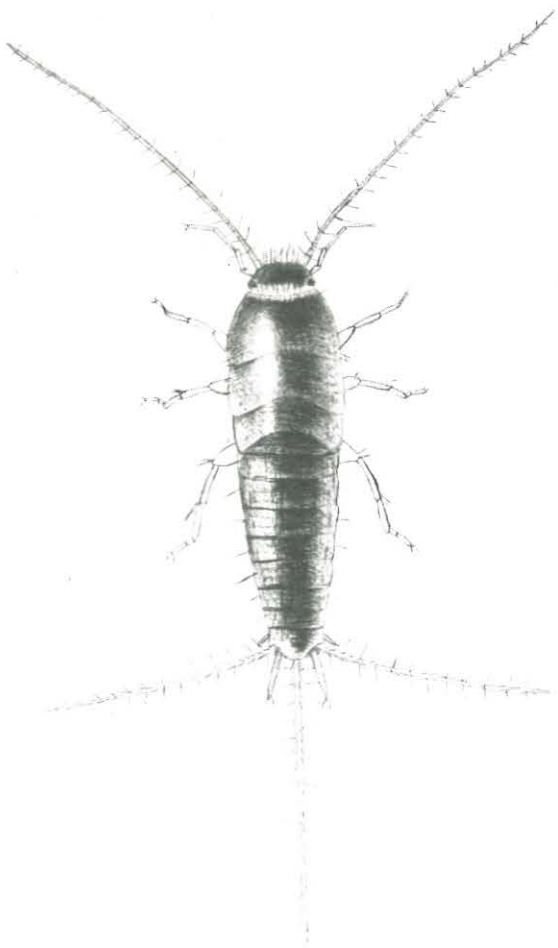


FIGURE 62

Silverfish

period, maintenance of warehouses in clean condition, storage at low temperatures or in insect-proof containers, frequent inspection, and use of insecticides.

2. PURCHASE OF INSECT-FREE PRODUCTS. Products liable to insect damage should be inspected at the time of purchase to ensure that no infested material is stored. Food-processing plants handling Navy contracts should be inspected periodically, and infested food should be rejected. Food contracts should stipulate that all deliveries be free of insects and that food-processing plants maintain a high degree of insect control.

3. WAREHOUSE SANITATION. Sanitation should be rigidly observed in depots and warehouses where food or clothing susceptible to insects is stored. Small accumulations of food materials and woolen lint in floor cracks support infestations which carry over into new stocks. Broken containers, torn sacks, or other spillage should be removed promptly. Cereal products intended for human consumption should not be stored near infested animal feeds. Goods returned to depots for salvage are often infested and should be fumigated before being carried into warehouses where they might contaminate clean stocks.

Cleanliness and good sanitation are essential where meats are stored. This includes proper disposal of trimmings, scrubbing floors and warehouse equipment, and frequent changes of sawdust on floors. The interiors of freight cars and trucks should be inspected for insects prior to loading outgoing shipments.

4. STORAGE CONDITIONS. Storage at temperatures below 50 F arrests development of existing insect infestations and prevents further contamination and damage. Temperatures in food warehouses should be kept as low as possible in winter without freezing perishable goods. Use artificial cold storage, when available, to kill out small infestations or to prevent their growth. In summer or in warm climates, materials should be stored under as dry conditions as are compatible with the nature of the particular type of goods. Insects tend to develop in larger numbers in such products as wheat flour, other cereal products, and whole grains, when these materials have a higher moisture content than normally.

5. INSECT-PROOF CONTAINERS. Few insects can gain entrance to properly sealed packages. Tightly sealed cartons, reinforced paper bags, or fabric bags with paper liners usually protect flour and other foods from infestation in transit and temporary storage.

B11.07 DDT SPRAYS

A 2½-percent DDT spray of water-dispersible DDT powder (QMC Stock No. 51-I-158) is effective for treating warehouses, and should be applied to walls and woodwork at the rate of 1 gallon to every 1,000 square feet. Weevils and other insect pests of foodstuffs, crawling on or burrowing in walls or woodwork, are killed as they come in contact with the DDT residues. Be careful, however, to avoid contamination of food when spraying.

B11.08 PRODUCT TREATMENT

1. FOOD PRODUCTS. A systematic program of fumigation should be developed for depots and warehouses to kill insects, or their eggs, that may be in food products to be shipped. Apparatus for this purpose should also be available to treat in-

coming materials likely to bring infestations to warehouse stocks. Chamber fumigation is a satisfactory system for small storages. Fumigation programs should be approved by higher headquarters and carried out by competent and specially trained and experienced personnel.

Cured meats are fumigated with hydrocyanic-acid gas in accordance with Federal regulations, and when the fumigation is approved by Federal meat inspectors. The use of this fumigant requires extensive precautions and training for adequate protection of all personnel concerned.

2. FABRICS. Fabric and fur mothproofing should be done during the manufacturing process, but insect damage to stored fabrics may be further prevented by use of flake naphthalene or paradichlorobenzene, or by residual treatment with DDT sprays. Sprinkle crystals of flake naphthalene or paradichlorobenzene among stored items at the rate of 1 to 2 pounds for every 100 cubic feet of storage space, and keep storage rooms closed and as airtight as practicable. Bales, surfaces of containers, and the interior walls of storage rooms should be sprayed with nonstaining DDT residual spray.

3. CHAMBER FUMIGATION. Fumigate food products, clothing and other materials known or suspected to be insect-infested (Figure 63) in gastight vaults or chambers equipped with exhaust fans. Stations desiring to construct a chamber should request technical assistance from the Bureau. Portable and nonportable types of fumigation chambers are available (see Appendix B) for use in the methyl-bromide delousing of clothing. Operators of fumigation chambers are selected and trained for this work.

a. Procedure. Stack the materials to be treated in the chamber so that there are at least 4 inches of free air space between the stacks and walls, with separation strips between layers to permit circulation of the gas. When the chamber is loaded, close, seal and lock the door, and apply the proper dosage of fumigant for the required period. Remove the gas with the exhaust fan and thoroughly air the chamber and its contents before unloading.

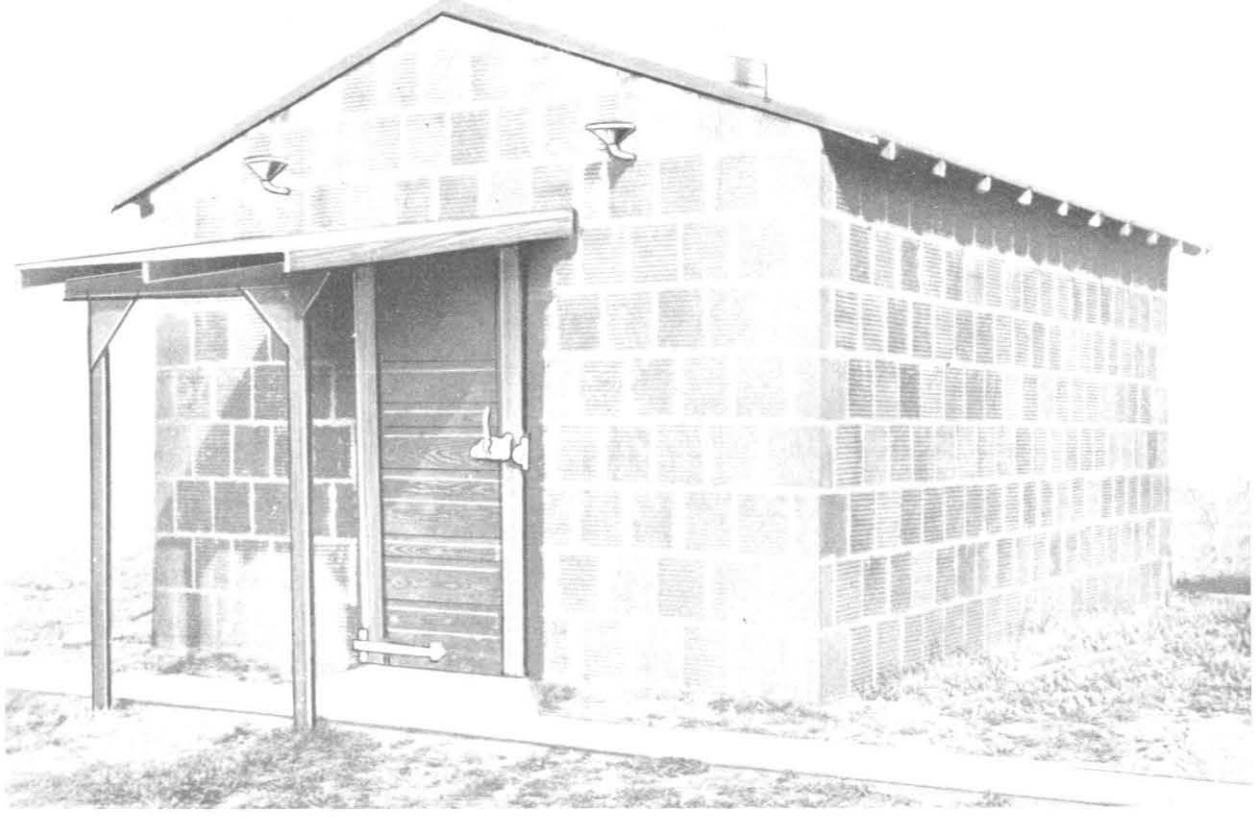


FIGURE 63

Outdoor Fumigation Chamber

b. Dosage. Methyl bromide, generally used in chamber fumigation, is released with an applicator supplied by the manufacturer, or through a piping system with outside connections. Dosages range from 16 to 24 ounces for every 1,000 cubic feet of space. The exact dosage is determined by the density of the materials to be fumigated.

B11.09 GENERAL FUMIGATION OF BUILDINGS

Fumigation is an effective means of eliminating insects and rodents in relatively airtight buildings. Because of the hazards to personnel involved, however, building fumigation should be undertaken only upon arrangement with higher authority. Fumigation has no residual effect, and a fumigated space may become reinfested soon after treatment. The fumigation of mess halls and barracks is not recommended as residual insecticides are more effective and economical. It is also widely used for the disinfestation of subsistence items and clothing. (See paragraphs B11.08 and B14.01.)

Section 12. INSECTS ATTACKING GRASSED AREAS

B12.01 GENERAL

Extensive areas at naval installations are planted to grass or other suitable vegetation to control erosion and dust. These plants are subject to numerous damaging pests, chief of which are Japanese beetle grubs, white grubs, mole crickets, grasshoppers, armyworms and earthworms, whose distribution varies with different parts of the country.

B12.02 CONTROL OF SUBTERRANEAN INSECT PESTS

1. JAPANESE BEETLE GRUBS. Grubs of the Japanese beetle develop from eggs laid about July, usually in grass sod. They feed on roots, especially grass, and emerge from the ground as adult beetles the following June. (See Figure 64.) (See also Section 13.) Grassed land in infested areas should be inspected semiannually for damage. Dead patches of sod that lift easily by hand indicate infestation, and when such patches occur, samples of soil should be examined for the curled-up, whitish grubs. Japanese beetles are limited to the eastern United States.

a. Control With Lead Arsenate. To grubproof grassed areas, lead arsenate may be applied at the rate of 10 pounds to 1,000 square feet. The chemical may be mixed with about 25 times its

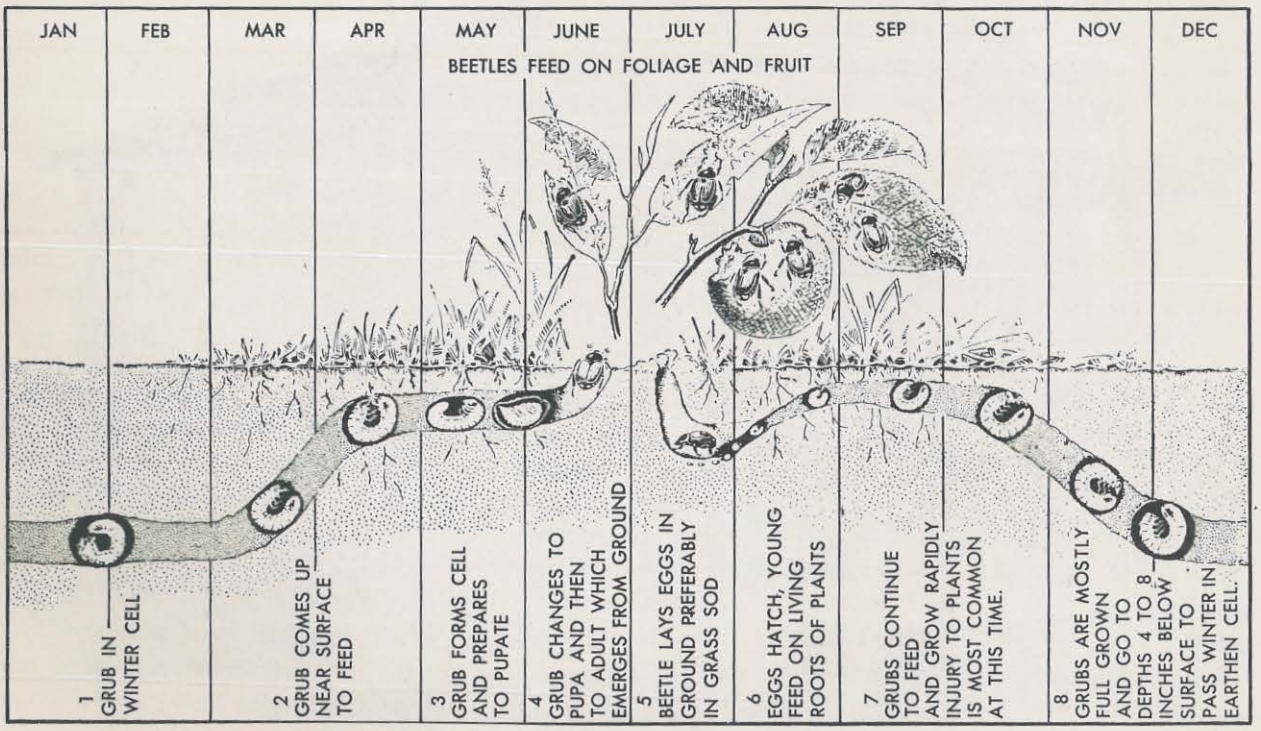


FIGURE 64

Life Cycle of the Japanese Beetle

volume of moist sand, soil, or other suitable material, and applied with a fertilizer spreader. It may also be applied as a spray with a power sprayer at any time that the ground is not frozen. Immediately after treatment, rake and water the ground to wash the poison into the soil. Bar people and animals from treated areas until the poison has been washed in. One treatment may be expected to protect sod from the Japanese beetle grub for five years.

b. Control With DDT or Chlordane. Either DDT or chlordane may be used in place of lead arsenate to grubproof grassed areas. One pound of actual DDT or ½ pound of actual chlordane per 1,000 square feet, applied as directed for lead arsenate, is an effective treatment.

c. Control With Milky Disease. Japanese beetle grubs die when attacked by milky disease. The spore dust of this disease may be obtained commercially, mixed with talc as a carrier, and spread with an ordinary, hand-operated corn planter fitted with a rotary disk adjusted to deliver about 1 level teaspoonful at 10-foot intervals. One and three-quarter pounds of spore dust are sufficient for the treatment of 1 acre of sod. Although the spores remain alive in the soil for a long time, several seasons of treatment may be required, following initial treatment, before maximum effectiveness is attained.

d. Traps. To determine whether Japanese beetles are present in an area, traps designed especially to catch adult beetles should be installed during the flight period of these insects in spring and early summer (Figure 65). The trap and its chemical attractant are standard, recommended by the U. S. Bureau of Entomology and Plant Quarantine; specifications may be obtained from that bureau. Traps are not recommended as a control measure, however.

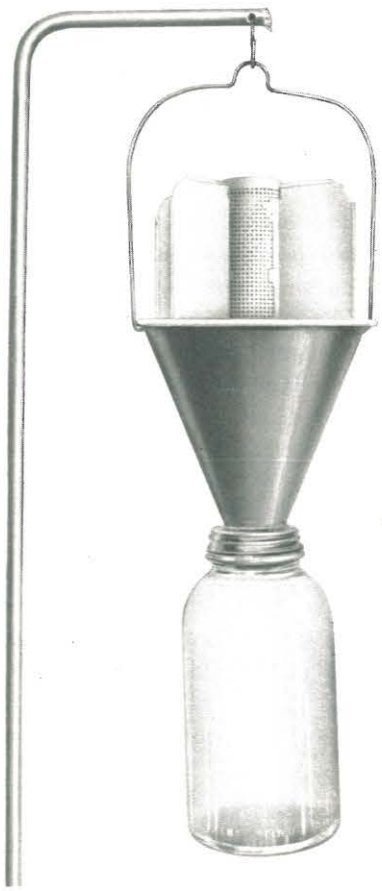


FIGURE 65

Japanese Beetle Trap

2. WHITE GRUBS. White grubs are the larvae of May beetles or June bugs (Figure 66). They are similar to Japanese beetle grubs, but are larger when fully grown and require two years to become adult beetles. They feed on roots of grasses and other vegetation and are particularly damaging to turf in the North Central States (Figure 67). The damaged sod may be lifted in the same manner as turf injured by the Japanese beetle grub.

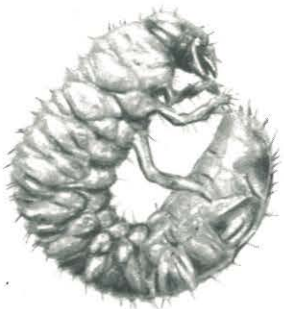


FIGURE 66

White Grub

White grubs may be controlled with lead arsenate, DDT, or chlordane in the same manner as directed for control of the Japanese beetle.

3. MOLE CRICKETS. Mole crickets are fat, brown insects, with shovel-like front feet re-

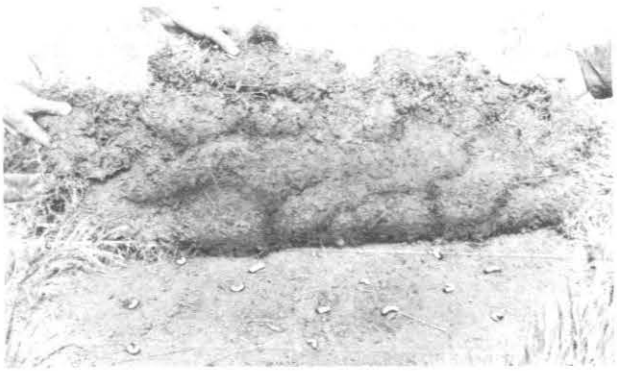


FIGURE 67

Grass Roots Injured Badly Permitting Sod To Be Rolled Back To Expose White Grubs

sembling the forefeet of a mole, that burrow in the upper two inches of the soil. They may seriously damage grassed areas from North Carolina to Texas.

Mole crickets feed near the surface at night and may be controlled with poisoned bait. The best time for baiting is in August and September when they are young and require the most food. The recommended bait formula is:

Wheat bran	100 lb
Sodium fluosilicate	8 lb
Water enough to moisten	3 to 5 gal

Mix the sodium fluosilicate thoroughly with the bran so that every particle of bran is covered with poison. Add water until the mixture is adhesive enough to form a loose ball when some is squeezed in the hand yet will break up into its individual particles when distributed. Corn meal may be substituted for the bran but is less satisfactory. In mixing the bait, be careful not to inhale the dust, and wear a dust respirator that protects the entire face if much is to be mixed.

Broadcast the bait evenly over infested areas at the rate of 20 pounds of dry bran (from 27 to 30 pounds of the moistened bait) to the acre. It is estimated that a single application will kill about three-fourths of the mole crickets in a given area. A second application, and possibly more, should be made at intervals of 10 days.

4. ANTS. Ants often throw up mounds of earth that disfigure grass turf and walks. They nest under stone and brick ornamental edging of grassed plots. For their control, see Section 9.

B12.03 CONTROL OF INSECT GRASS PESTS ABOVEGROUND

1. GRASSHOPPERS. Grasshoppers occur in destructive numbers most often in the western part of the United States and may almost completely destroy vegetative cover over wide areas, leaving the soil subject to erosion by wind and rain. They lay their eggs in masses from ½ to 2 inches below the surface of the soil. Most species winter in the egg state, a few as partly grown hoppers. Technical assistance should be requested when they threaten serious damage.

Aldrin, chlordane, and toxaphene give better initial results and continue to kill longer than the older insecticides.

On range vegetation and dense succulent growth, these insecticides are more effective when sprayed. Baits poisoned with these materials are more effective than sprays in dry vegetation. Ready-to-mix emulsion concentrates and water-dispersible powders containing varying proportions of aldrin, chlordane, or toxaphene are available commercially. Oil solutions are also procurable but are more likely to injure vegetation.

Whatever the preparation, or its dilution, the quantity of actual chemical applied as a spray per acre should be 2 ounces of aldrin, from ½ to 1 pound of chlordane, or from 1 to 1½ pounds of toxaphene. The higher dosages of chlordane and toxaphene are required when vegetation is tall and dense, or when long-continued killing action is desired. Poison baits are prepared and applied much as described in paragraph 3 of B12.02 for mole cricket control. The following proportions of ingredients are used:

Mill-run bran	25 lb
Sawdust, 3 times the volume of bran	3.5 bu
Aldrin (actual)	2 oz
Water	10–12 gal

Either ½ pound of chlordane or 1 pound of toxaphene may be substituted for the aldrin. Spread the bait uniformly by hand or with spreading machines at the rate of 20 pounds of wet bait per acre. Observe strictly precautions for handling these insecticides. (See paragraph B14.03.)

2. MISCELLANEOUS PESTS OF GRASSED AREAS. A number of caterpillars, particularly armyworms, cutworms, and webworms, may damage grasslands severely. Sometimes chinch bugs also must be destroyed. Control of these insects often involves special problems and the cooperation of entomologists should be obtained for control recommendations.

Section 13. INSECTS THAT DAMAGE TREES AND SHRUBS

B13.01 GENERAL

Trees and shrubs at naval installations prevent dust and erosion and improve working conditions and morale. Insects that damage such plants fall into three general classes, chewing insects, sucking insects, and wood and bark borers. The type of control measure to be used depends largely on the class of insect.

B13.02 CONTROL MEASURES

1. RESISTANT VARIETIES OF PLANT. Wherever possible, plant a species of tree or shrub more resistant to insect attack.

2. REFUSE DISPOSAL. Weeds, useless scraps of lumber, and other refuse furnish insects with favorable hibernation locations and should be destroyed.

3. USE OF INSECTICIDES. Insecticides are often an effective method of insect destruction.

B13.03 CHEWING INSECTS

1. JAPANESE BEETLE. Not only the larvae (grubs) of this insect cause damage to sod (paragraph 1 of B12.02); adult beetles live on the foliage of many kinds of trees and shrubs from mid-June into August. The insect occurs in most of the states east of the Mississippi River, except those bordering on the Gulf of Mexico, and is most damaging from Massachusetts and New York south to Virginia. The beetle is about ½ inch long and is a metallic green, with reddish-brown wing covers.

2. ELM LEAF BEETLE. The elm leaf beetle breeds throughout the warm months and occurs in the eastern states and on the west coast. It is not known in most of the midwest. The foliage of elm trees attacked by it and its larvae is often skeletonized and becomes a yellow or brownish color. The beetle is ¼ inch long and dull green. (See Figure 68.)

3. TENT CATERPILLARS. These hairy caterpillars infest many fruit and forest trees, with the exception of conifers (pines, spruces, and so on), and often strip a tree entirely of its leaves. Eastern tent caterpillars (Figure 69) construct a protective community web or tent in a tree crotch and spin silken paths to the leaves on which they feed. The forest tent caterpillar is similar, but does not construct a tent. Tent caterpillars are troublesome from May to the end of June and occur in most of

FIGURE 68

Elm Leaf Beetle and Leaf Damage

FIGURE 69

Tent Caterpillars and Their Tent

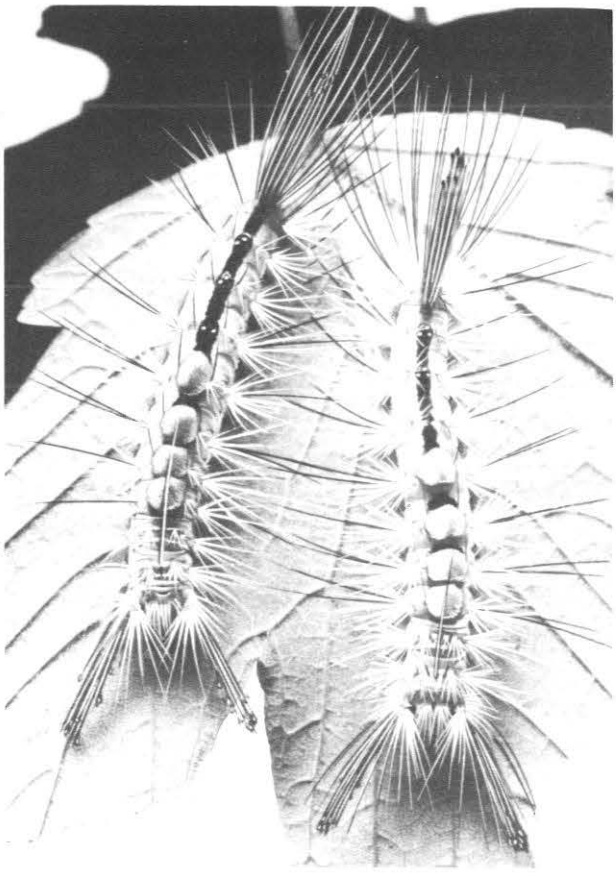


FIGURE 70

Caterpillars of the White-Marked Tussock Moth

the United States. When not too numerous, accessible tents may be destroyed by hand.

4. CANKERWORMS. These brownish-green moth larvae (measuring worms) hatch from eggs laid in the branches and twigs of trees and feed on the foliage. They attack elms and many other shade trees, and may occur in such numbers in the spring and early summer as to strip trees and shrubs. (A band of sticky substance painted around the tree trunk, 4 or 5 feet above the ground, in February or March will help to prevent such attacks since the female moth is wingless and must climb the tree to lay her eggs.)

5. WHITE-MARKED TUSSOCK MOTH. The hairy caterpillars of this insect (Figure 70) are also destructive to the foliage of most kinds of shade trees, except conifers. They occur east of the Rocky Mountains in the United States but are less serious in the south than farther north. There are two or three generations of the caterpillars a season so the insect may cause damage practically all summer.

6. FALL WEBWORM. The fall webworm is another hairy caterpillar that constructs a community tent. But unlike the eastern tent caterpillar, it makes a loosely woven tent enclosing the leaves upon which it feeds. This species also feeds on most shade and woodland trees except the conifers, and occurs generally over the United States and southern Canada. When the tents are accessible and not too numerous, they may be destroyed by hand.

7. CATALPA SPHINX. The caterpillars of this large moth grow to 3 inches long, are blackish, with dark-green markings, and have a sharp horn at the tip of the body. They feed only on catalpa and often entirely defoliate the tree. They are widely distributed in the United States.

8. BAGWORMS. The larvae of this insect live in tough, silken bags with bits of leaves attached,

hanging from the twigs and leaves of infested trees (Figure 71). Practically all trees are attacked, and stripped trees may die. The winter is passed in the egg stage within the bag. Unless very numerous, the bags on small trees may be picked by hand and burned in winter.

FIGURE 71

Bags of the Bagworm Fastened to a Cedar Twig

B13.04 CONTROL WITH INSECTICIDES

1. DDT. The elm leaf beetle, catalpa sphinx, tent caterpillar, tussock moth caterpillar, and cankerworm may be destroyed with DDT, but the insecticide must be in a form that can be mixed with water and, from the standpoint of safety to plant life, be a water-dispersible powder. The spray should contain 1 pound of DDT (2 pounds of 50 percent powder) for every 100 gallons of water. When it is used for Japanese beetles, foliage should be sprayed 2 or 3 times every 10 days.

2. LEAD ARSENATE. Leaf-eating insects may also be controlled with lead arsenate mixed with water at the rate of 3 to 6 pounds per 100 gallons of spray.

B13.05 SUCKING INSECTS

1. GENERAL. Many plant-damaging insects feed by piercing the surface and sucking the sap. They may usually be controlled with chemicals that kill on contact. Treatment may be by either spraying or dusting directly, or by treating the plant with a residual insecticide (sometimes DDT is effective) that kills when the insect walks over it. Sucking insects include aphids (plant lice), scale insects, and leafhoppers. Spider mites, although not insects at all, are somewhat similar to the sucking insects in their habits and control, and are therefore discussed here. (Often small chewing insects, such as young caterpillars and the larvae of leaf beetles, may also be destroyed with contact insecticides.)

2. APHIDS (PLANT LICE). Aphids are tiny, soft-bodied insects, generally green but sometimes black, brownish, or reddish (Figure 72). There are many kinds living on a wide variety of plants, concentrating their attacks mainly on new, succulent growth with abundant sap, that reduce plant vigor, curl the leaves, and prevent the normal formation of flowers.

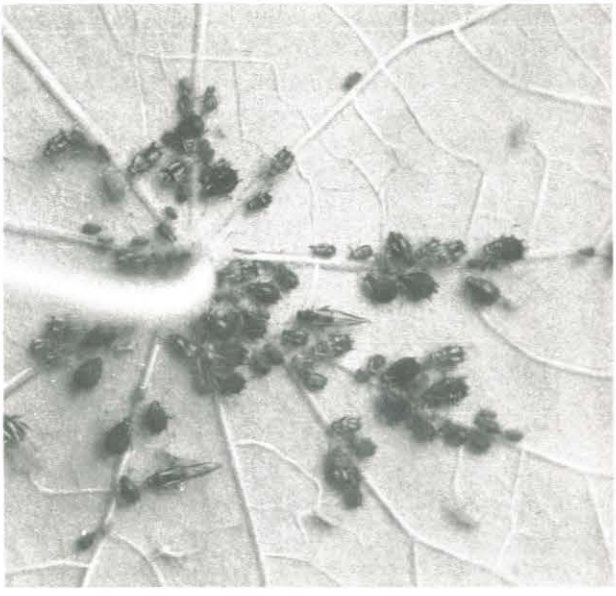


FIGURE 72

Colony of Aphids on Underside of Leaf

Aphids and some other soft-bodied insects may be killed with nicotine sulfate sprays (40 percent nicotine content). Spray once or twice, as necessary to gain control, using a mixture of 1 pint of nicotine sulfate and 5 pounds of dissolved soap powder in 100 gallons of water. For smaller amounts, mix 1¼ teaspoons of nicotine sulfate and 1 tablespoon of soap powder in 1 gallon of water. The soap is added so the spray will wet the insects well.

Various preparations containing either pyrethrum or rotenone are effective against aphids and similar pests, but they differ in strength and should be used according to the manufacturer's directions. DDT, as applied for Japanese beetles, is not effective against all kinds of aphids but will kill pests such as leafhoppers, treehoppers, and spittle bugs.

3. SCALE INSECTS. There are many kinds of scale insects, but the commonest are the oyster-shell and pine needle. Generally, they are microscopic

in size and cover themselves with a hard, waxy, protective substance that becomes the scale from which they derive their name. They cling closely to the plant surface on which they settle and lay their eggs under the scale. The young insects, after hatching, emerge and move about until they find a suitable place to settle.

a. Oyster-Shell Scale. This insect is brownish-gray, about ⅛ inch long, and is usually shaped like a tiny oyster shell (Figure 73). It is a common insect that attacks many kinds of ornamental trees and shrubs, such as elm, poplar, dogwood, soft maple, and lilac, living on the bark of these plants. The eggs hatch in the spring.

FIGURE 73

Twig Infested With Oyster-Shell Scales (Somewhat Enlarged)

Dormant, petroleum oil sprays used at 3 percent of actual oil are effective if applied during the late fall or early spring (in winter if in a mild climate) when the trees are bare. A spray mixture of 2 pounds of 50 percent wettable DDT in 100 gallons of water is also effective if used in the late spring just as the young scale crawlers are hatching.

b. Pine Needle Scale. This scale insect is white, and often locates on the needles of pines and other evergreens in such numbers that the needles appear splashed with whitewash. The insect is distributed throughout the northern United States and southern Canada and generally has two generations a season.

Dormant fall or spring spraying with a lime-sulfur solution is recommended for control of the pine needle scale. It is applied at a strength of 1 gallon of the solution concentrate to 8 gallons of water. Oil sprays should not be used on evergreens in fall or winter.

4. SPIDER MITES. These microscopic pests often occur in such large numbers as to yellow the foliage and cause leaves to drop from shrubs and trees, and are particularly injurious in periods of hot, dry weather. Arborvitae, cedars, hydrangeas, and roses suffer severely. The mites (sometimes called red spiders, though usually they are not red)

FIGURE 74

Damage to Hemlock Foliage by Spider Mites (Note Silk Webbing Spun by the Mites)

spin almost invisible silk webbing on the undersides of the leaves (Figure 74).

Dusting finely ground sulfur (300 to 325 mesh) on affected plants is one method of control. If a spray is desired, mix 1 pound of wettable sulfur in 3 gallons of water. Keep the suspension thoroughly mixed while spraying.

B13.06 TREE BORERS AND BARK BEETLES

1. GENERAL. Numerous insects tunnel under the bark or in the wood of trees (Figures 75 and 76). Some kinds only attack trees in a weakened or sickly condition, but many others attack healthy trees. Shade trees should be kept in vigorous condition with adequate water and plant food.

a. Tree Removal. Dying trees should be felled and burned, or otherwise removed from the vicinity of healthy trees to prevent infestation of the latter.

b. Treatment of Insect Burrows. Treat

large shade trees showing castings beneath burrow openings in the trunk with injections of small quantities of carbon disulfide poured into each opening with an oil can, and seal the holes immediately.

2. BRONZE BIRCH BORER. Birches, especially white or paper birch, poplars, cottonwoods, and willows are liable to attack and destruction by this borer. Browning of the tips of upper branches is the first evidence of infestation. Small holes,

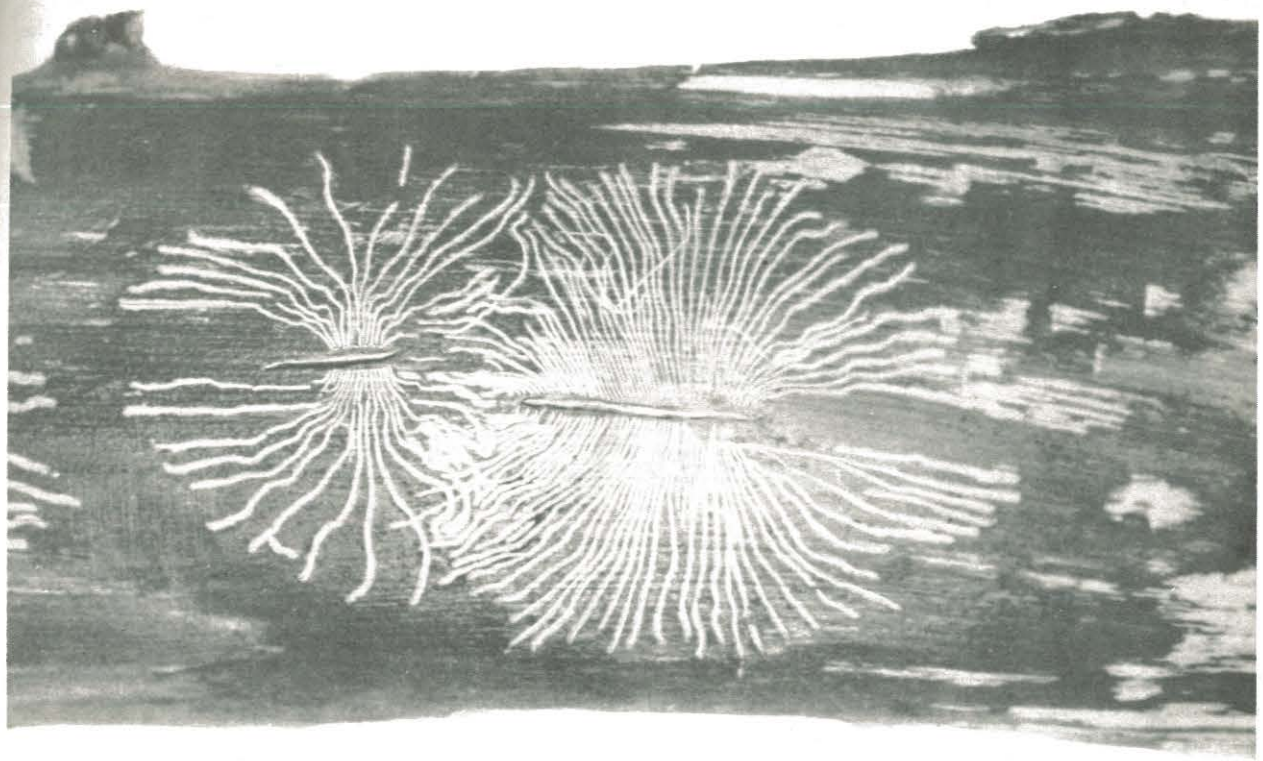


FIGURE 75

Work of Bark Beetles Under Tree Bark

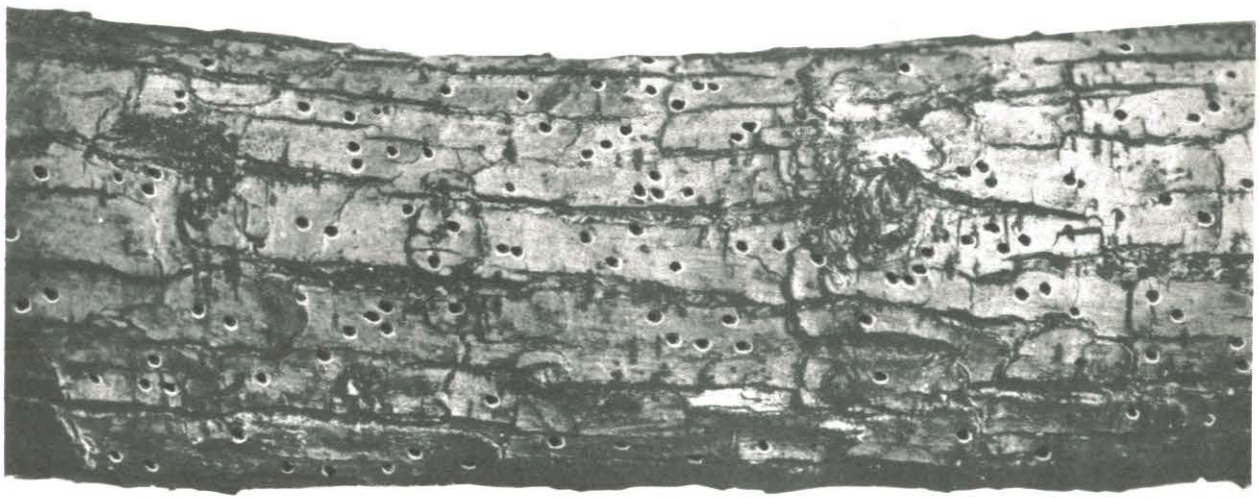


FIGURE 76

Holes in Bark Made by Bark Beetles

about ⅛ inch in diameter, will be seen in the bark. The insect is destructive generally throughout the northern United States and southern Canada east of the Rocky Mountains.

Trees should be kept vigorous. Wrap the trunks with paper from the ground to the lowest limbs during May, June, and July when the adult beetles are present and laying their eggs. Infested parts of trees should be cut out and burned during the winter.

3. ELM BARK BEETLES. The native elm bark beetle and the smaller European species are tiny beetles that carry the destructive fungus causing Dutch elm disease. The disease occurs as far west as Colorado and is widespread in the eastern and north central states. Leaves wilt and fall on certain branches of infected trees, larger limbs put out numerous suckers, and dying twigs show a brown ring beneath the cambium layer. Bark beetles flying from diseased trees carry spores of the fungus to healthy trees, spreading this deadly disease of elms.

Remove diseased trees or parts of trees as promptly as possible, and burn them to prevent the attraction of the bark beetles to feed, lay their eggs, and spread the disease to nearby healthy trees.

4. LEAD CABLE BORER. A boring beetle, known as the lead cable borer, cuts round holes through the lead sheathing of aerial cables in California and frequently is the cause of line failure. This insect, however, is normally a wood borer.

Section 14. USE OF CHEMICALS AND EQUIPMENT FOR INSECT CONTROL

B14.01 USE AND TYPES OF INSECTICIDES

1. USE. The proper use of the present concentrated and toxic insecticides requires trained and qualified personnel to prevent accidental sickness or loss of life. The proper safeguards require knowledge of each type of insecticide and its most effective form of application, as well as the precautions involved. Chapter 10 of the Manual of Naval Preventive Medicine outlines this information with reference to each formulation, and should be obtained as a guide for all personnel responsible for pest-control operations. This section lists the insecticides and their most widely accepted uses, and deals with the application procedures in general.

2. SPRAYS. Most sprays are prepared by: (a) diluting either a wettable (water-dispersible) powder or a liquid emulsion concentrate with water; (b) dissolving some suitable material, such as DDT, in kerosene or fuel oil; or (c) diluting an oil-base concentrate with kerosene or fuel oil. Oil-base sprays are also available in diluted form ready to apply.

3. DUSTS. Ready-prepared dusts generally contain insecticide blended with talc, or a similar inert diluent, and conditioned for most efficient use. Usually it is impractical and wasteful to prepare one's own dust dilutions. In emergencies, however, a prepared dust may be further diluted if proper diluents are available.

4. FUMIGANTS. Some gaseous or gas-forming insecticides, such as methyl bromide, may be used in special cases requiring fumigation. Because more effective sprays and dusts are now available, they should be used in place of fumigants to avoid the hazard of handling poisonous gases.

B14.02 KINDS OF INSECTICIDES

Although several kinds of insecticide will be listed here, Appendix B should be consulted for items for general supply.

1. ALDRIN. Aldrin is a new insecticide highly effective in grasshopper control (paragraph 1 of B12.03). It is used as an emulsifiable concentrate and as a wettable powder.

2. BENZENE HEXACHLORIDE (BHC). A benzene hexachloride emulsifiable concentrate, 11 percent gamma isomer, is being made available as a standard item of issue for outdoor application. Concentrations of BHC spray are normally not in excess of 0.5 percent to allow maximum safety in application. The uses of BHC are essentially the same as lindane (paragraph 7 of B14.02). The principal advantage is the lower cost for treatments.

3. CHLORDANE. Chlordane, although similar to DDT, is superior for some purposes but its residual effect is not so long-lasting. It is particularly effective against cockroaches and ants and may be used to kill DDT-resistant flies and mosquitoes when lindane or BHC is not available.

It is also useful for control of Japanese beetle grubs and grasshoppers. Use an emulsifiable concentrate (46 percent chlordane), diluted with water, for spraying vegetation.

A 2-percent chlordane solution in kerosene is available in 1-gallon (Navy Stock No. G 51-I-155-375) and 5-gallon (Navy Stock No. G 51-I-155-385) containers for residual spraying. The concentrate, however, must be used only under supervision of trained personnel, and, because of the toxic effect of chlordane vapors, must be used with care in unventilated places.

4. DDT. DDT has many uses, but is not effective against all insect pests. Except where these insects have developed resistance, it is effective as a residual and space spray against adult flies, mosquitoes, and mosquito larvae, and is highly effective in the control of bedbugs, lice, and fleas. It is available in several preparations, according to the use to which it is to be put. Five percent DDT in a kerosene solution, emulsion concentrates, dispersible powders for water dilution, and 10-percent DDT dust are the commoner preparations. Water-dispersible powder is effective against many leaf-eating beetles, caterpillars, and sucking insects. Diluting pure DDT in the field for use as a dust should not be attempted because special grinding facilities are required to obtain the necessary small particle size. When advisable, pure DDT may be diluted with kerosene or fuel oil to obtain a 5 percent solution. Higher concentrations should not be attempted because of the tendency of DDT to crystallize, especially at low temperatures. A solution approximating 5 percent may be prepared by adding 2 pounds of DDT to each 5 gallons of oil. This amount of commercially pure DDT fills a No. 10 food can about two-thirds full. In mixing large quantities, 20 pounds of DDT may be added to a drum of oil from which 5 to 6 gallons have been removed. Constant stirring for an hour will aid in dissolving the powder. Another method of dissolving the powder is to leave the drum in the sun, rolling it occasionally.

5. DIELDRIN. Dieldrin is one of the effective new insecticides that has been found particularly effective in fly control but is also restricted to outdoor use. Dieldrin is very toxic to mammals. The standard catalog item G 51-I-156-1625 is an emulsifiable concentrate requiring approval of the Bureau of Medicine and Surgery prior to use. It is used in very low concentrations of 0.3 to 0.5 percent, and may become much more widespread in use as more information regarding toxicity is available.

6. LEAD ARSENATE. A water suspension of lead arsenate is often used to control leaf-eating insects. Lead arsenate is also applied to the soil for the control of Japanese beetle grubs. Lead arsenate is a cumulative poison that must be carefully used and applied in areas where repeated applications have been made.

7. LINDANE. Lindane is a purified form of the gamma isomer of benzene hexachloride and should be used only under supervision of trained personnel. It should not be applied repeatedly as a space spray in greater concentrations than 0.5 percent. Special instructions should be requested from higher headquarters before using lindane in a vaporizer. It is available as an emulsifiable concentrate, and like chlordane, the effect of its deposits is not so long-lasting as DDT. Lindane may also be used for controlling DDT-resistant mosquitoes and flies, and is effective against a number of other insect pests, including ants.

8. METHYL BROMIDE. Methyl bromide possesses special penetrative properties as a fumigant, and may be used for fumigating lice-infested clothing and items in tight storage. Methyl bromide is odorless, colorless, and heavier than air. Gas masks with special canisters must be worn by trained personnel.

9. NAPHTHALENE. Flake naphthalene is sometimes used to protect stored items from fabric pests.

10. NICOTINE SULFATE. This liquid insecticide is often used in the control of soft-bodied insects, such as aphids. This compound is normally procured in a 40 percent concentrate of extremely toxic nature. Caution must be exercised in protecting mixing personnel when diluting to normal application sprays.

11. PARADICHLOROBENZENE. This is a white flaky material similar to flake naphthalene and is often used to protect woolen fabrics and similar items. It is also used to kill fly larvae.

12. PETROLEUM OILS. Kerosene, fuel oil (No. 2), and diesel oil may be used as solvents in the field preparation of DDT larvicides and residual sprays. When DDT is not available, these oils themselves may be used for killing larvae in mosquito-infested waters. (See paragraph 3c of B1.07.)

13. PYRETHRUM AND ALLETHRIN. Extracts of pyrethrum flowers, when present in sprays containing DDT, aid in killing flies and mosquitoes. Aerosol bomb-type dispensers usually contain either pyrethrum extract or a new synthetic, allethrin, as a pyrethrum substitute.

14. ROTENONE. Rotenone is derived from derris or cube plants. It is used as a spray or dust for controlling soft-bodied insects that attack vegetation.

15. SULFUR. Sulfur is used to control spider mites, either as a dust or suspension.

16. THIOCYANATES ("LETHANE"). Lethane is the trade name for a group of synthetic organic thiocyanates used in space sprays in place of pyrethrum.

17. TOXAPHENE. This compound is similar to aldrin in its effectiveness against grasshoppers, and is used as an emulsifiable concentrate.

18. INSECT REPELLENTS. Mosquito repellents are available in 2-ounce bottles (Navy Stock No. G 51-D-237-400).

19. OTHER INSECTICIDES. Sodium arsenite, coal-tar creosote, pentachlorophenol, and trichlorobenzene may be used in termite control. They are always diluted before use (paragraph 4b of B10.05). Sodium arsenite is also used to kill fly larvae.

B14.03 PRECAUTIONS IN USE AND STORAGE OF INSECTICIDES

Personnel responsible for the application and use of insecticides should be thoroughly familiar with the precautions and restrictions outlined in Chapter 10, Manual of Naval Preventive Medicine and applicable Bureau of Medicine and Surgery Instructions of the 6250 series.

1. OPERATOR PROTECTION.

a. Mixing and Applying Materials. Take the following precautions when mixing, applying, or handling insecticides: (Inexperienced personnel should be instructed in the precautions to be observed, and supervised until trained.)

(1) Keep materials out of mouth and eyes.

(2) Avoid inhaling insecticidal dusts or mists.

(3) Avoid prolonged contact with insecticides. (Insecticide solutions such as DDT, chlordane, lindane in oils, and other organic solvents may be absorbed through the skin and should be handled with care to prevent contamination of skin and clothing.)

(4) Wash face and hands with soap and water after handling chemicals.

(5) Change clothes twice a day if necessary to keep chemicals from skin; bathe each time.

(6) Do not allow spray and dust residues to accumulate on clothing.

(7) Keep hose and pipe connections tight; maintain cut-off and control valves with positive action. (These measures will aid in avoiding contamination of skin and clothing and will save materials.)

(8) Know characteristics of insecticide being used, its effect on man, animals, plants, finished surfaces, fabrics, and other materials.

b. Protective Devices. Suitable goggles, respirators, gloves, and coveralls should be worn by operators, especially while spraying or dusting indoors, using soil poisons for termites, and treating wood for powder-post beetles.

(1) *Respirators.* Use mechanical-filter respirators approved by the United States Bureau of Mines to provide protection from metallic, mineral, and nuisance dusts, and mists produced in spraying operations. When spraying liquid pesticides, organic fume cartridges should be used on respirators.

(2) *Gloves.* Use gloves made of tough fabric with a synthetic coating resistant to oils, greases, petroleum solvents, acids, corrosive chemicals, and abrasives. Rubber latex gloves are also satisfactory.

(3) *Gas Masks.* When using fumigants, provide gas masks equipped with proper canisters to prevent the operator from inhaling poisonous fumes. Requests for fumigation must be submitted to higher authority. Fumigation is extremely hazardous and must be done only under supervision of thoroughly trained personnel.

2. RESPONSIBILITY IN HANDLING POISONOUS MATERIALS. Poisonous material should not be handled in a way that will expose other persons, domestic animals, or wild life to unnecessary hazards.

a. Contamination. Prevent contamination of food and drinking water, when spraying mess halls, by covering or removing all food, dishes, and utensils.

b. Residues. Avoid leaving residues of poisonous insecticides on plants used as food by humans or livestock. Oil-base and emulsified

sprays may also injure vegetation if applications are excessive, and the former deteriorate rubber.

Emulsions, suspensions of wettable powder, and kerosene-base sprays, when applied to dark-colored or polished surfaces, such as furniture, automobiles, and windows, also leave a white, spotty residue. These surfaces should be cleaned with water or wiped with furniture oil. Tinted or papered walls should not be given a general spray treatment, and freshly painted surfaces should not be sprayed. If there is doubt as to the effect of a spray on a particular substance, test a small area before making a general application.

c. Fire Hazards. When kerosene solutions of DDT are used as residual sprays by trained personnel, it is assumed that no explosion hazard exists unless open flames or temperatures exceeding 100 F are present, but recommended fire-prevention practices should be observed. Permission to use emulsions or solutions containing solvents other than those mentioned in this manual should be obtained from higher authority.

d. Clearance. Clear all operations of a questionable nature with the senior medical officer or his delegated representative.

3. SAFE STORAGE OF INSECTICIDES. Stock rooms should be dry and clean. A supply of insecticides to meet normal requirements for from 60 to 90 days should be kept on hand, clearly labeled, and under lock and key to prevent waste and improper use. Insecticides should never be stored with food. Fire hazards of some insecticides should be considered in locating storage space.

B14.04 FIRST AID SUGGESTIONS

(1) Notify medical officer immediately of an accident involving poisonous materials.

(2) Give recommended first-aid treatment immediately and remove victim to hospital as soon as possible.

(3) Give victim nothing to drink if unconscious.

(4) Keep unconscious victim lying down until medical officer arrives.

(5) If victim is cold, wrap him in blanket or other suitable covering; do not apply hot objects.

(6) If victim has stopped breathing, apply artificial respiration.

B14.05 EQUIPMENT FOR APPLYING INSECTICIDES

1. GENERAL. Equipment for applying insecticides ranges in size from small hand applicators to large power-driven units delivering from 40 to 50 gallons of spray per minute. Equipment also varies from that used on the ground to the type used in aircraft. Some sprayers deliver smoke-like fog, others a coarse spray. Dusts, however, are delivered by still other types of equipment.

2. SIZE OF SPRAY PARTICLES. For a residual spray, the nozzle should be held close to the surface, delivering a coarse spray that wets the surface without forming a fine mist. (Particles in a fine mist float away, resulting in waste of insecticide.) When an enclosed space is to be sprayed, a fog-like spray is desired to fill it with fine particles of insecticide that remain suspended in the air for a considerable period. These fogs, or aerosols, may also be used outdoors for treating an area infested with flying insects.

3. SPRAYING EQUIPMENT.

a. Plunger-Type Hand Sprayers. These sprayers are used with sediment-free insecticides. Two types are available, one intermittent in action, discharging spray with each forward stroke of the piston, the other discharging continuously on both forward and backward strokes (Figure 77). Plunger-type hand sprayers are usually equipped with a fine-spray nozzle. When equipped with adjustable or interchangeable nozzles, the sprayer delivers a fine spray for space treatment or a coarse, wetting spray for residual applications. Continuous-type hand sprayers are available from stock.

FIGURE 77

Continuous-Type Hand Plunger Sprayer

b. Compressed-Air Sprayers. Sprayers of this type (1- to 5-gallon capacity) are suitable for applying residual sprays to buildings and small outdoor areas. They are also used for larviciding water areas that are not too extensive. In operation, air is pumped over the spray liquid in the tank by a built-in, plunger-type pump to give from

FIGURE 78

Cylindrical Compressed-Air Sprayer

30 to 50 pounds pressure (Figure 78). With various nozzle disks, the spray pattern and particle size may be varied as desired. The insecticide should be stirred by shaking the sprayer during operation. Compressed-air sprayers are available as Navy Stock No. G 41-S-4125.

c. Hand-Operated Fog Applicators. These applicators are compact, portable and hand-operated, and develop a fine mist. They consist of a pressure chamber containing a floating piston separating the permanent charge of nitrogen gas from the spray liquid. Operating pressures range from 350 to 1,000 pounds. Highly concentrated chemicals can be used so that the required dosage of insecticide is applied quickly and with only a small output of total liquid.

d. Wheelbarrow Sprayers. Wheelbarrow sprayers are the largest of the hand-operated mobile spray units. They are used in spraying buildings and grounds not readily accessible to power equipment and too extensive for portable hand sprayers. The tanks have a capacity of 12 to 18 gallons. The spray liquid is agitated mechanically. Pressures up to 250 pounds may be developed.

e. Aerosol Dispensers (Bomb Type). Hand-operated aerosol dispensers are metal containers capable of resisting internal pressures. (See Figure 79.) They contain a mixture of insecticide solution and a suitable liquefied gas which provides pressure to discharge the insecticide in a fine mist. Aerosol bombs are convenient for individual use in space-spraying buildings, tents, and other small enclosed spaces. Discharges for 3 to 4 seconds are required for each 1,000 cubic feet of interior space. These dispensers are also used outdoors for temporary protection from flying insects when the air is still.

FIGURE 79

Aerosol Bomb Dispenser

f. Electric Sprayers. Electric sprayers are suitable for applying insecticides in large buildings such as warehouses and barracks. Some models develop space sprays of the aerosol type, some a coarse spray for residual treatments, and others develop both types.

g. Power-Operated Hydraulic Sprayers. This type is used extensively for residual treatments of buildings, vegetation and grounds, and for larviciding mosquito breeding areas. Pressure is developed by direct action of the pump on the spray liquid, forcing the liquid through one or more nozzles. Models capable of spraying from 1 to 50 gallons a minute are available. Some of the larger models develop maximum pressure up to

600 or 800 pounds, but they are also designed to operate on lower pressures, permitting their use in applying residual sprays in buildings at low pressures or in applying larvicides where higher pressures are needed to throw a spray stream a considerable distance. Mechanical agitators are often provided in the tanks to permit the use of abrasive insecticides. Tank capacities range from about 10 to over 400 gallons. Some sprayers are skid-mounted, others are wheel-mounted.

h. Pneumatic Power Sprayers. These sprayers are used for the same work as hydraulic types, and employ the same principle as the compressed-air sprayer, except that pressures for discharging spray are developed by an air compressor. To develop sufficient pressure, however, the tank must be airtight. The working pressure of these sprayers is about 125 pounds.

i. Mist Blowers. Mist blowers, a relatively new type of sprayer, are used for outdoor residual and larvicidal applications. They use higher-concentrated insecticides than older types of sprayers. The insecticide is sprayed into an air blast that further breaks up the liquid and carries it along in the air stream. These machines are effective at ranges up to several hundred feet, depending on terrain, vegetation, and direction and velocity of the wind. Larger models are usually skid-mounted for use on boats, trucks, or trailers.

j. Fog or Aerosol Generators. These sprayers are used to treat areas with a space spray for controlling flying insects. The fog-like spray is usually applied advantageously when air conditions are favorable and when insects are likely to be in flight. The slight movement of the air is used to carry spray over the areas under treatment. To be effective, treatment should be given to areas less than 300 feet wide. These generators are also used for nonresidual space treatment in large buildings. Principal types of fog generators are thermal generators, converted military-type smoke generators, steam aspirators, combustion-chamber units, engine-exhaust generators, jet-type generators, and centrifugal or rotor-type generators. A jeep-mounted Todd Insecticidal Fog Applicator (TIFA) (MIL Spec. 1098A) is versatile equipment for fogging and misting to control mosquitoes at large naval bases and stations where trained personnel are available (Figures 80 and 81). The capacity of this machine is from 30 to 40 gallons per hour. Operating directions should be obtained from BuMed. The MIDA duster (Figure 82) is an obsolete, converted smoke screen generator for the

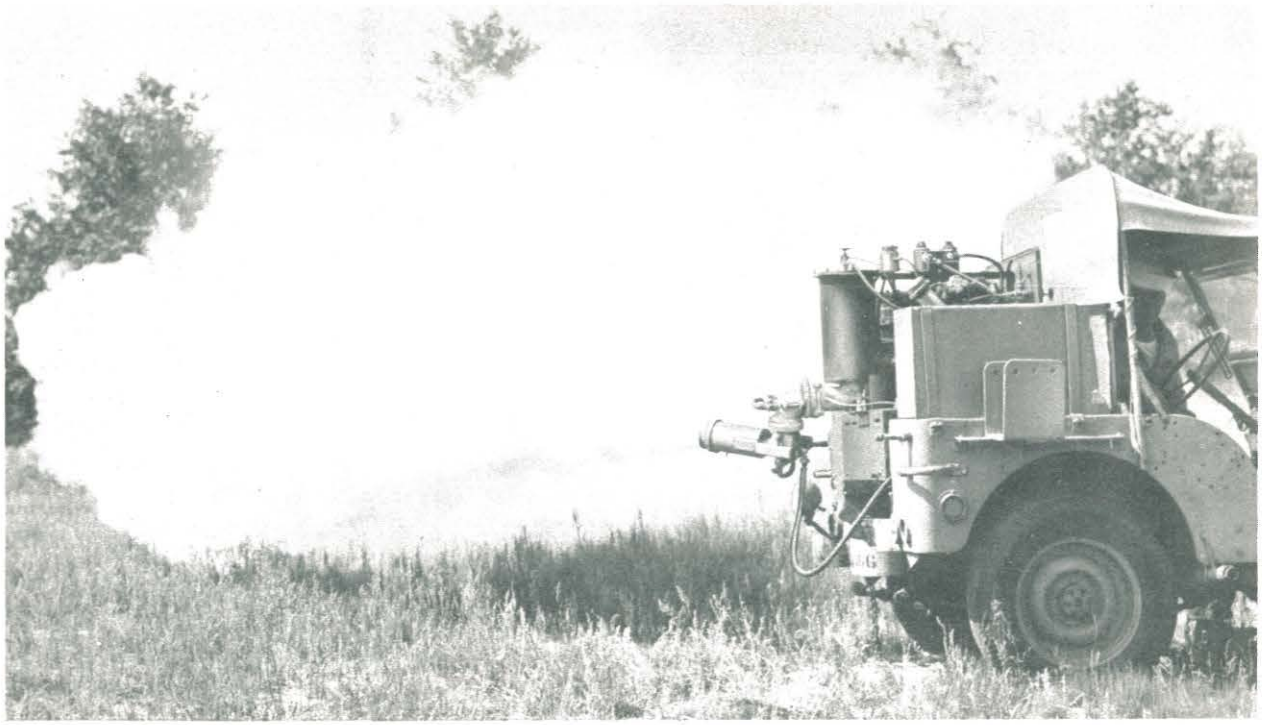


FIGURE 80

Mosquito Control Spraying Equipment (TIFA Jeep Mount)

application of insecticide. The cost of conversion is considerably less than that of conventional equipment intended for the same purpose.

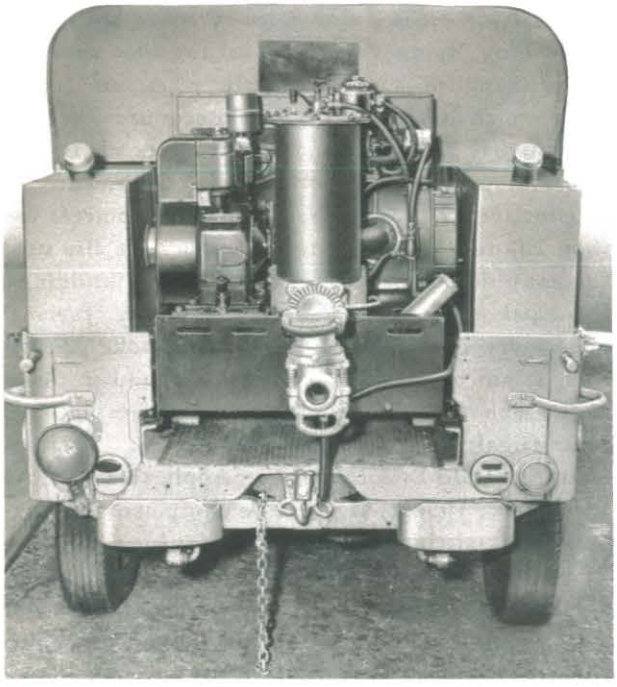


FIGURE 81

Fog Machine: TIFA Model 40E Mounted on Jeep

4. AIRCRAFT SPRAY DISPERSAL EQUIPMENT. No single type of plane can be used in all aerial insecticidal operations. Size of area, nature of terrain, and distance from airfield must be considered. Planes used in these operations range from light, single-engine planes capable of carrying from 25 to 40 gallons to transport and bomber-type planes capable of carrying up to 1,600 gallons of insecticide. Light planes are used to treat small areas of less than 100 acres.

Uniform, effective, and wide distribution of insecticides is the objective of aerial spraying (CNO CirLet 46-2182). Equipment consists of a tank, liquid distribution lines, and a discharge device (Figure 83). Insecticide may reach the outlet by gravity flow, or be pumped to that point under pressure. When pumped, the flow is uniform despite the changing level of the liquid in the tank. Any one of several nozzles may be used for dispersal. Sometimes a breaker bar is used, consisting of a tubular boom with small holes for discharging the liquid. The breaker bar is placed so that the particles in the liquid, on hitting it, are broken up to a greater degree. Straight discharge pipes are often used on larger and faster aircraft, the rate of discharge regulated by changing diameter and length of the pipe.

FIGURE 82

Mosquito Control Spraying Equipment (MIDA Duster)

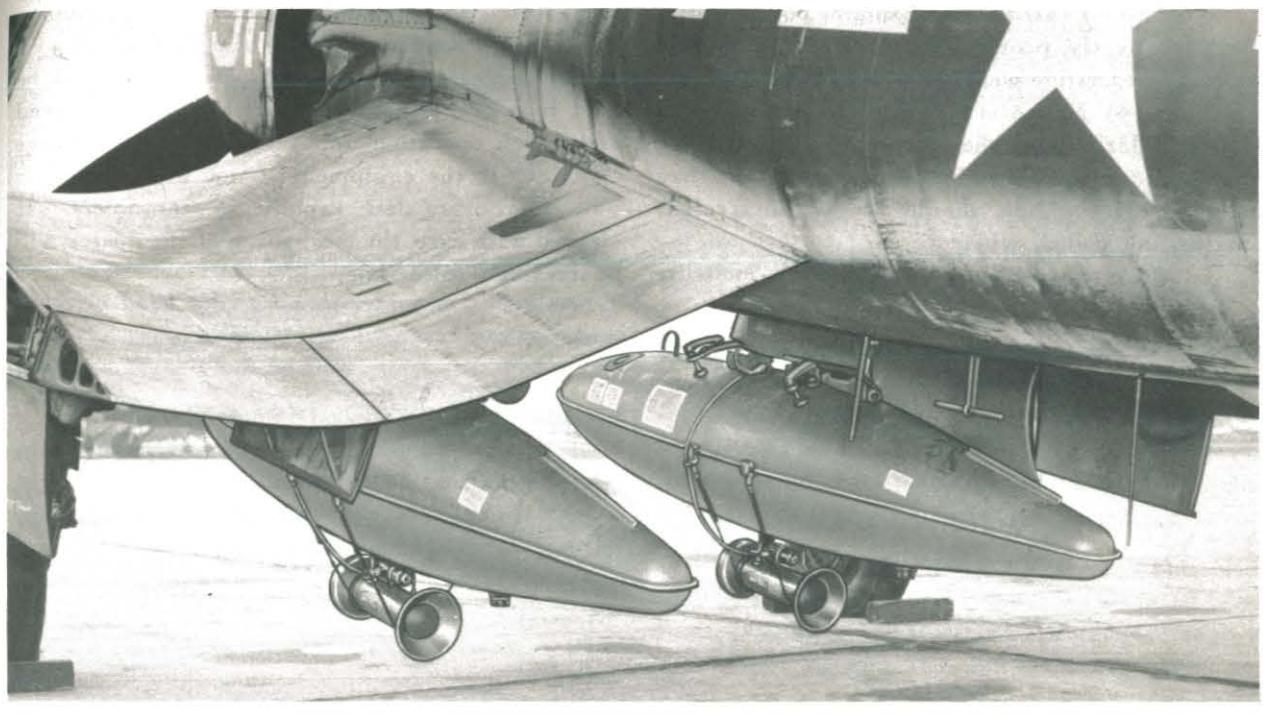


FIGURE 83

Spray Gear on Airplane

5. DUSTING EQUIPMENT.

a. Plunger-Type Hand Dusters. The plunger-type duster has a chamber holding up to 1 quart of dust. This hand duster is intermittent in action and will deliver the insecticidal dust only a few feet beyond the nozzle (Figure 84).

FIGURE 84

Plunger-Type Hand Duster

b. Crank or Rotary-Type Dusters. This type of duster has a capacity for from 5 to 25 pounds of dust and is carried in front of the operator, secured to him by shoulder straps. It is continuous in action and throws dust farther than the plunger type of duster. (See Figure 85.)

6. CARE OF EQUIPMENT. Proper care of equipment is essential for satisfactory service. Moving parts should be kept well oiled. Rough handling must be avoided to prevent costly repairs. All equipment should be cleaned and overhauled during the off season.

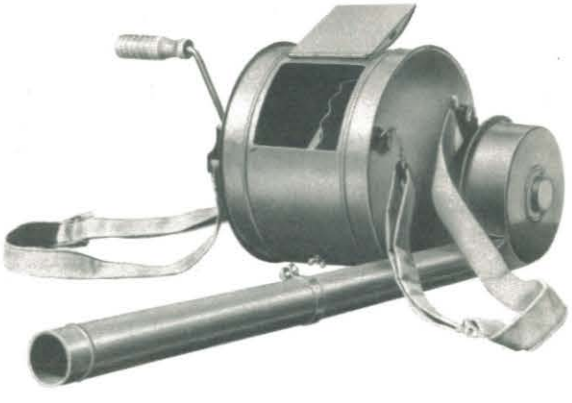


FIGURE 85

Rotary Hand Duster

a. Spraying Equipment.

(1) *Water.* Use clean water to dilute spray materials.

(2) *Flushing.* Flush all sprayers thoroughly, including tanks, hose, and nozzles, after each day of use and before storage. Oils and solvents may adversely affect gaskets and hose connections, and wettable powders often settle and cake to clog hose and nozzles.

(3) *Examination.* Examine power equipment frequently, providing replacements for parts subject to excessive wear.

(4) *Hose Storage.* Hose should be stored in a cool, dark place when not in use. In addition, hose should be hung on a broad support rather than on nails. Heavy hose should be laid in straight lengths, not coiled, when stored.

(5) *Cold Weather.* Drain all moisture from stored equipment when there is a possibility of freezing. Radiators should also be drained.

b. Dusting Equipment. Dusters should be kept in a dry place, and dust should be removed after each operation and returned to its storage container if the equipment is not used often. It will deteriorate less rapidly in containers. If cleaned with care, the mechanism of the duster will be less likely to corrode.

PART C. RODENTS AND OTHER PEST ANIMALS

Section 1. RATS

C1.01 GENERAL

Rats are secretive and largely nocturnal in their habits. They carry disease, and are omnivorous feeders, though each species has certain food preferences.

1. DISEASES CARRIED BY RATS. Bubonic plague is carried by rats and may be transmitted to man by the bite or feces of a flea that has fed on a plague-infected rat. Endemic, or murine, typhus is also conveyed to man by the rat flea (a form of typhus distinguished from epidemic typhus and carried from man to man by the body louse). Infectious jaundice, or Weil's disease, may be contracted through contact with food polluted by the urine of rats. Food poisoning is often caused through infection by certain bacterial organisms that may be transmitted in rat excreta deposited on prepared foods. Rats are also reservoirs of tularemia and scrub typhus and, in addition, transmit rat-bite fever, dysentery, trichinosis, and rabies.

2. DESTRUCTION OF FOOD AND PROPERTY. Rats eat and contaminate large quantities of food such as cereals and meats, frequently gnaw on slaughtered-livestock carcasses and dressed poultry being held in cold storage; and hairs brushed from their fur contaminate materials over which the animals pass. Rats often severely damage buildings and equipment, and cause fires by gnawing and short-circuiting electrical wiring.

C1.02 COMMON KINDS OF RATS

1. BROWN OR NORWAY RAT. The Norway rat is a heavy species, weighing from 10 to 17 ounces, or more, with a short tail (Figure 86). It is a burrowing animal found mainly in basements, earthen banks and dumps, or around the lower floors of buildings, and nests in burrows beneath floors or concrete slabs, and rubbish piles. It is widely distributed in the north temperate zones of the world.

2. CLIMBING RATS. The roof or Alexandrine rat, the black or ship rat, and the frugivorous rat

FIGURE 86

Adult Brown or Norway Rat

are smaller animals weighing from 4 to 8 ounces. They are good climbers, with a greater feeding and scouting range than the Norway rat, usually occupy the upper parts of buildings (preferring to nest in attics, trees, and shrubbery), and are seldom found in burrows. They are found throughout the warmer parts of the world, and especially at Gulf coast ports in the United States.

3. PACIFIC ISLAND RATS. There are many kinds of small field rats in the Pacific area, from Burma, the Malay Peninsula and various intervening island groups, to the Hawaiian Islands. They are frequently plague-infected. The Hawaiian rat, an example of these species, weighs from 2 to 3 ounces, has an average body length of 4 to 5 inches, and a tail of the same length. It burrows and nests in fields and embankments. Several types of medium-to-large tree or wood rats, generally spiny-furred, are prevalent in heavily wooded sections of larger islands in the western Pacific region.

C1.03 EVIDENCE OF RAT INFESTATION

1. DROPPINGS. Rat droppings are rod-shaped and, when fresh, black or dark brown, glistening, and have a putty-like consistency. Old droppings are hard and often covered with dust or mold.

2. RUNWAYS. Rats travel over the same routes, and soon produce well-defined runways. Footprints are sometimes visible, and dark greasy marks are left wherever they rub against a wall or pipe along their runways or at the edge of a hole or barrier. Runways in active use are usually shiny and free of dust.

3. TRACKS. Rat tracks in dust or flour are characterized by the four-toed prints of the front paws and the broken, wavy line made by the dragging tail.

4. BURROWS. Rats make burrows for hiding places, nesting, and to enter buildings (they have been known to dig several feet vertically to pass under a foundation wall). The burrows usually range from 12 to 18 inches deep.

5. NESTS. Nests may be found in trees and buildings as well as in burrows.

6. SIGNS OF GNAWING. Fresh marks of gnawing also indicate rat infestation. Spaces under and around wooden doors and windows are readily enlarged by gnawing to permit entry by rats. Young rats can pass through a ¾-inch opening.

C1.04 CONTROL

1. GENERAL. Rat control, to be successful, is a matter of thorough, concerted action. Rat populations must not only be reduced, but conditions favoring their return must be eliminated. Any effective control program must also be continued on a maintenance level (or after initial success the rodent population will revert to its former status) and should provide for all of the following phases: (a) ratproofing of buildings; (b) elimination of harborage; (c) elimination of food supply; and (d) destruction of rats.

2. RATPROOFING BUILDINGS. Ratproofing existing buildings and providing ratproof features in new construction are vital to rat control. External construction of buildings accessible to rats should be of materials that resist their gnawing. Cement, 12- or 15-gage galvanized hardware cloth with ¼- or ½-inch mesh, and sheet metal of 26 gage or heavier, are all suitable ratproofing materials. Openings larger than ½ inch in the exterior of a building must be closed. Openings such as unused doorways, gratings, or windows less than 4 feet from the ground through which rats may enter should be covered with ½-inch hardware cloth. Openings around boxed-in piping and wire leads should be closed. Conduits for wiring should be limited to sizes too small for rodent passage. Fire stops in double walls and floors of wood construction should exclude (Figure 87) potential rat runways along beams, and spaces between walls should be blocked. Doors should be self-closing and tight-fitting. Wooden sills and doors at ground level can be sheathed in sheet metal to prevent gnawing. Foundations should extend at least 3 feet below the surface of the ground. Programs for ratproofing buildings should be coordinated with those units responsible for care and construction of buildings and should receive adequate technical supervision.

3. POISONING. Poisons (rodenticides) that may be mixed with food baits are the most efficient means of wholesale rat destruction, and their use has the further advantage that burrows need not be located. (Most poisons, however, are dangerous for humans and domestic animals, so poisoning should be fully authorized and have proper technical supervision.)

a. Kinds of Poison. Four rodenticides are available, red squill powder, zinc phosphide, warfarin, and sodium fluoroacetate. (The last one

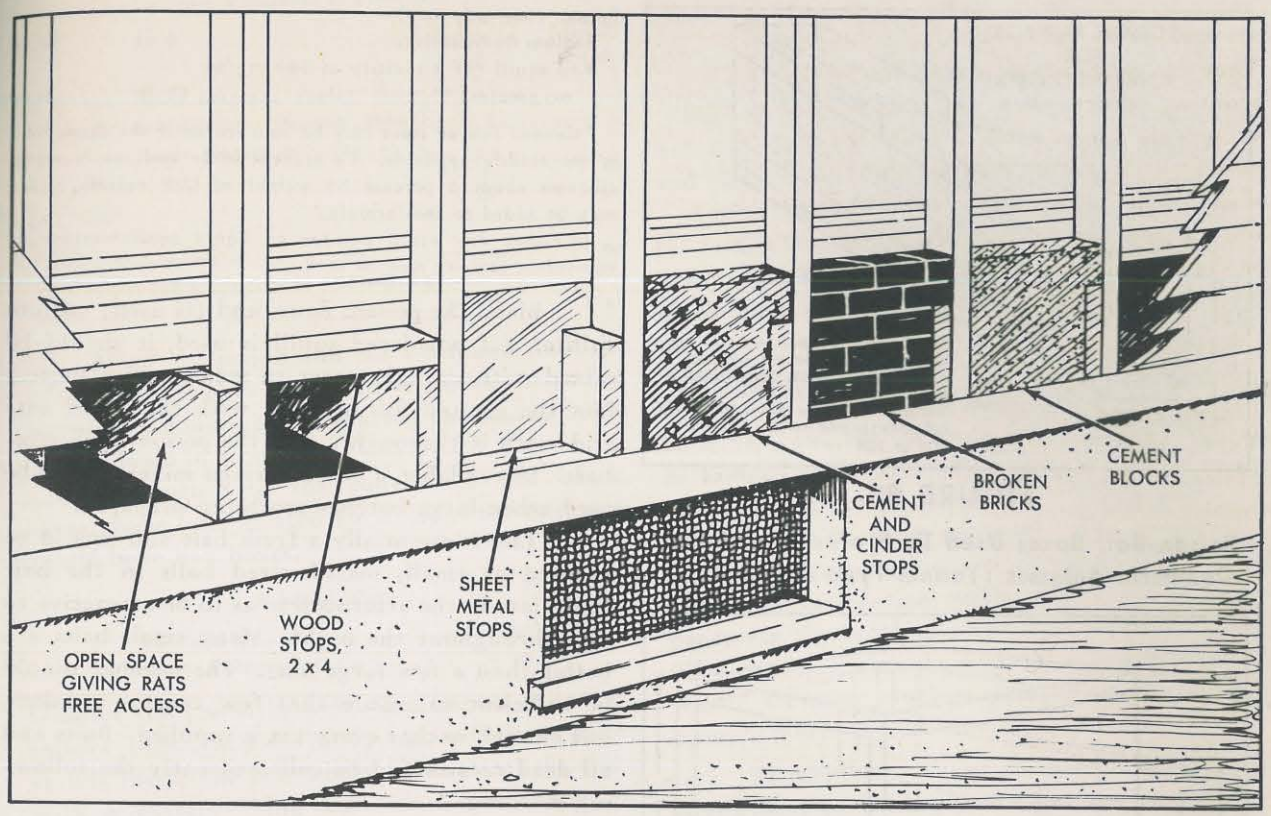


FIGURE 87

Ratproofing

may be obtained only on approval of BuMed.) See BuMed Instruction 6250.1.

(1) *Red Squill.* Red squill is considered the least dangerous for domestic animals and humans because of its emetic factor (rats are unable to vomit).

(2) *Zinc Phosphide.* Zinc phosphide is highly toxic and has an offensive odor. Rats appear to be attracted to it, however, but most domestic animals will not touch baits containing it.

(3) *Warfarin.* Warfarin is an anticoagulant chemical which, when taken by a rat daily over a period of several days, causes death by internal bleeding. Permanent, covered bait stations are very good for furnishing supplies of bait large enough for several feedings.

(4) *Sodium Fluoroacetate.* Sodium fluoroacetate (1080) is soluble in water and the solution has no warning flavor, but because of its extreme toxicity for man and other animals, is very dangerous to use. The poison does not disintegrate after being swallowed by a rat; therefore, cats or dogs eating dead or dying rats will also be killed.

b. Baiting. Samples of different classes of foods should be placed for one or two nights in locations frequented by rats to determine which foods are most readily accepted. Food preferences differ according to the species, geographical area, and a number of other conditions. Test samples should be chosen from the three classes, cereals (bread, oatmeal, cornmeal, poultry mash), proteins and fats (meat, fish, waste cooking grease, peanut butter), and fruits and vegetables (melons, sweet potatoes, bananas). All other foodstuffs should be made inaccessible to rats.

After determining the most attractive food, prepare prebaits. These do not include the poison, but are handled the same as poisoned baits. Protecting baits from contact with the hands is not necessary because rats are not repelled by human scent. Prebaiting is carried on for approximately a week, with daily observations and replacement with fresh bait as necessary. Then all uneaten prebaits are gathered, destroyed, and replaced with poisoned bait.

Bait boxes or feeding stations should be made to protect baits from weather and as a safeguard for irresponsible persons, children, and pets. (For construction details see Figures 88 and 89.) These stations also furnish runways and

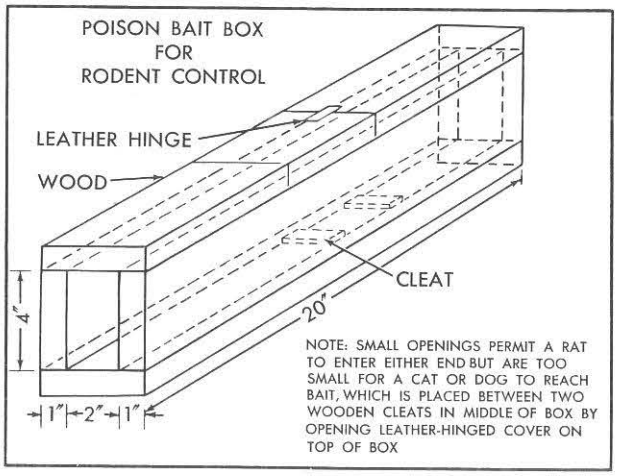


FIGURE 88

Poison-Bait Boxes Used To Protect Bait From Domestic Animals (Tunnel-Type Bait Boxes)

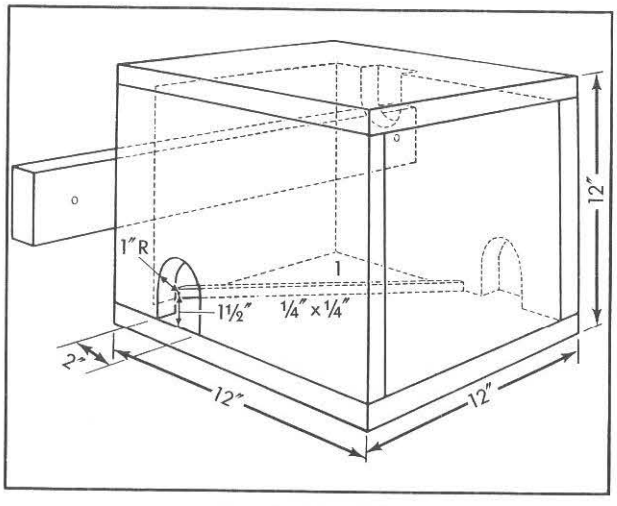


FIGURE 89

Twelve-Inch Cubical Box for Safeguarding Poison Baits

harborage attractive to rats when trash piles and other old rat shelters are cleaned up.

All poison baits (except warfarin) should be picked up after a 3-day poisoning period. A different poison should be used if a repeat period is necessary and, if test baiting indicates, another bait food. At least 60 days should elapse before follow-up poison baiting of the same area.

c. Bait Formulas.

Fresh Meat-Cereal Bait (Fresh Type)

	Large batch	*Small batch*
Ground fresh fish or meat *	50 lb	1.5 lb
Rolled oats (breakfast-food grade)	47 lb	1.5 lb
Wheat flour	2 lb	1 oz
Poison (use only one)		
Sodium fluoroacetate	4 oz	⅛ oz
Red squill (of a toxicity of 500 mg/kg or greater) **	11 lb	6 oz

*Canned fish or meat may be substituted if the fresh food is not readily available. To prevent early spoilage in warm climates about 1 percent by weight of USP sodium sulfite may be added to the formula.

** Either dry squill powder or liquid squill extract of equivalent toxicity may be used.

Blend the poison, flour, and (if used) sodium sulfite. (If powdered squill is used, it should be mixed with enough water to make a thin paste.) Mix the ground fish or meat with the rolled oats and work it thoroughly into the poison-flour mixture. If available, a power-driven mixer should be used when large batches are being prepared.

This is essentially a fresh bait and should be exposed as small, marble-sized balls in the bait boxes late in the afternoon so as to be attractive to rats throughout the night. Many small baits are better than a few large ones. The number should be sufficient to ensure that few remain untaken, but enough so that every rat is supplied. Baits and all dead rats should be collected early the following morning.

Pork Fat-Cereal Bait (Semipermanent Type)

	Large batch	*Small batch*
Ground fresh pork fat *	20 lb	14 oz
Rolled oats (breakfast-food grade)	78 lb	3 lb
Fish oil (poultry grade)	1 qt	1½ fl oz
Wheat germ oil	2 fl oz	1/10 fl oz
Poison (use only one)		
Sodium fluoroacetate	4 oz	1/6 oz
Red squill (of a toxicity of 500 mg/kg or greater) **	11 lb	6 oz

* If pork fat is not available, fresh waste fats may be used.

** Either dry squill powder or liquid squill extract of equivalent toxicity may be used.

Add the poison to the mixture of fish and wheat germ oils. Mix the ground, fresh pork fat with the rolled oats, add the poison-oil mixture and stir thoroughly, preferably with a power mixer when a large batch is being prepared.

This is a semipermanent type of bait that will remain acceptable to rats for several weeks. It should be exposed in the bait boxes, either as a loose bait in small piles of 1 or 2 ounces, or as torpedoes formed by wrapping about 1 teaspoonful of bait in a square of waxed or other strong paper (about 5 by 5 inches). Since rats can carry away the torpedoes and children or pets may find them, this method of exposing the poison should usually be confined to red squill baits.

Fresh Vegetable or Fruit Bait

	Large batch	*Small batch*
Fresh, raw sweet potatoes, apples, tomatoes, or cantaloupes (¾-inch cubes) used as single ingredients or as a mixture	98 lb	2 lb
Wheat flour	2 lb	1¼ oz
Poison (use only one)		
Sodium fluoroacetate	4 oz	⅛ oz
Red squill (of a toxicity of 500 mg/kg or greater)	10 lb	3 oz

Blend the poison and the flour and dust the mixture evenly over the cubed vegetables or fruits. Complete the mixing by bouncing the dusted cubes up and down in a bucket or small tub. This bait is especially suited to the control of the black, Alexandrine, and related forms of rats. Exposure should be in bait boxes.

Poisoned Water

Clean water	2 gal
Sodium fluoroacetate	1 oz

Dissolve the poison in water and expose it in containers (Spec. MIL-C-3305) or in shallow dishes or lids inside the bait boxes. These may be filled with a battery-filling bulb or a small-mouthed bottle with a pouring spout.

d. Warfarin Baits. Warfarin baits are made by thoroughly mixing 1 pound of 0.5 percent warfarin (QMC Stock No. 51-R-480) with 19 pounds of an attractive dry bait such as corn meal or rolled oats. Place from 4 to 8 ounces of this poison mixture in each protected bait station. Maintain the bait between 10 and 14 days, replenishing it before it is completely eaten, and replacing it with fresh bait if the original lot molds or decomposes, and burn bait residues. Warfarin baits must be eaten repeatedly by rats for several days, thus differing from the other rodenticides that kill the rat with a single dose. A dry bait is recommended to prevent rats from carrying the bait away. CAUTION: Do not smoke or eat while handling poisons. Articles employed for mixing poison baits, or that are to contain the poisoned bait or the poison itself, should be used for this purpose only, washed thoroughly after use, and kept separate from all other utensils. They should be plainly labeled *POISON*. Discarded bait containers should be burned or buried. Adhere strictly to safety precautions in the instruction sheets accompanying rodenticides.

4. FUMIGATION. Fumigation, or gassing, effectively destroys rat populations in treated areas and at the same time kills fleas that infest the rats and rat burrows. Only specially trained crews should fumigate buildings and outdoor rat burrows. (See paragraph B11.09.)

Rats often live in burrows deep in the ground, but opening outdoors, under and beside buildings and platforms.

Apply calcium cyanide dust (Navy Stock No. G 51-C-418) with a foot-held powder duster (Navy Stock No. G 41-D-4525). When the nozzle of the hose is inserted in the burrow opening, the pump forces the dust along the burrow. Another but less effective method is to throw 1 tablespoonful of the dust into the entrance of the burrow. In either case, the openings to the burrows should be tamped with earth afterward.

Calcium cyanide gives off a deadly gas and should only be used outdoors. Do not use this method to treat burrows in dirt-floored basements or beside foundation walls where the gas will penetrate the building. The dust pump should be filled outdoors with the operator standing to windward. Observe cautions printed on the calcium cyanide label.

5. TRAPPING. Traps are often valuable as a supplement to baiting and other rat control programs, but locating traps along protected runways to catch the rodents successfully requires skill and persistence. Large numbers of wood-base snap traps are recommended for this purpose (Figure 90). In humid climates the wood base should be

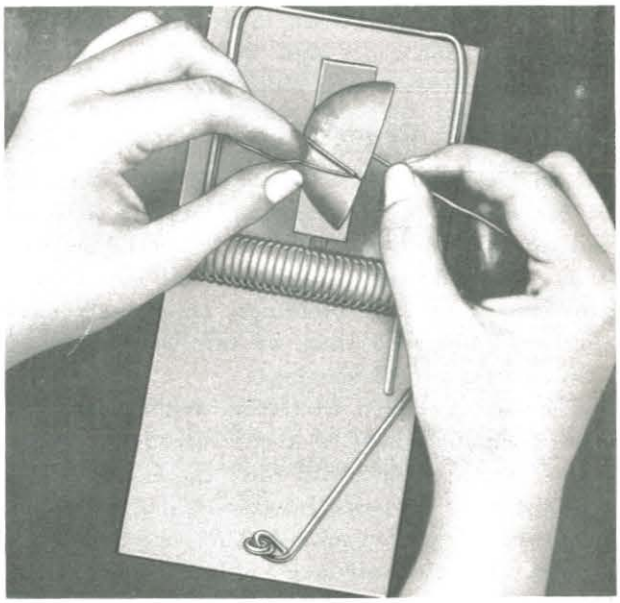


FIGURE 90

Wood-Base Snap Trap

soaked in linseed oil to prevent warping. Traps may be used with or without bait. Effective baits include bacon rind, nuts, fresh coconut, and bread or oatmeal dipped or mixed with bacon grease. When unbaited, the trigger pan of the trap should be enlarged with a piece of cardboard or lightweight sheet metal to provide a larger area for the rat to contact and snap the trap. Tend the traps daily, and do not allow dead rats to remain in them.

C1.05 ELIMINATION OF HARBORAGE

The elimination of hiding places is an essential part of rat control. Elevated platforms (pallet dunnage) with legs 24 inches high and covered with sheet metal provide considerable protection. Stacked materials should be located at least 2 feet from the wall, and all waste materials, such as broken equipment, boxes, trash, and garbage, should be disposed of by an approved method. (See *Refuse Disposal*, NAVDOCKS TP-Pu-1.) Open dumps often become heavily infested with rats and should be eliminated. Wooden floors in basements, boxed-in plumbing, closed platforms under equipment, pockets of hollow tile walls, hollow bases of shelving units, and insulated spaces around refrigerating and heating units are all favorite living quarters of rats. Such conditions should be either eliminated or made ratproof.

Proper handling of food and disposal of garbage are also important in rat control. Rats seek harborage convenient to favorable food supplies, but if food and shelter are eliminated, premises lose their attraction.

Section 2. MICE

C2.01 GENERAL

House mice and several field-inhabiting species cause damage at Navy installations. House mice are those most commonly found indoors, although certain field species may enter buildings in the autumn to escape the cold. Most common field species make trails under rank plant growth and mulch, which are clearly visible when the ground is exposed, and they frequently run in the tunnels of moles and gophers. Most species make their nests in short, simple burrows in the ground among the roots of shrubs and trees, in decayed stumps or hollow trees, and under logs. They tend to colonize, and usually produce several litters a year.

C2.02 KINDS OF MICE

1. HOUSE MICE. House mice (*Mus* species) have a wide distribution, occurring especially in and around buildings (Figure 91). Some, however, live outdoors during the summer and may destroy growing plants. In buildings, these pests have runways similar to those of rats but involving smaller crevices and openings.

They damage food containers and contaminate food, frequently hide in stored records and pamphlets, staining these with their excreta or shredding the paper for nesting material, and are known to spread disease organisms. They are characterized by their relatively long and hairless or sparsely haired tails.

2. MEADOW MICE. Meadow mice (*Microtus* species) are widely distributed in North America,

FIGURE 91
House Mouse Adult

Europe, and Asia. They are stocky little animals with coarse brown fur, small furry ears, and short, slender tails. Their presence is revealed by shallow burrows connected by a network of tiny trails under old grass or fallen vegetation. They are prolific, having five or six litters annually, each with about five young. These mice are most active in the early morning and late afternoon, feeding aboveground.

3. WHITE-FOOTED MICE. White-footed, or deer, mice (*Peromyscus* species) occur all over North America except in the far north. They do not make runways of their own, but use those of other mice. Their nests are made in locations similar to those of other species, and in abandoned bird nests on the ground and shrubbery. The tail is long, as is that of the house mouse, but well haired.

4. PINE MICE. Pine mice (*Pitmys* species) are found east of Kansas and Nebraska in the United

States. They are smaller and finer furred than meadow mice, with a short tail only slightly longer than the hind leg.

C2.03 CONTROL

1. TRAPPING. Traps of the wood-base snap type are smaller than the same type of rat trap, but methods of baiting and setting are the same as for trapping rats. Choker-loop mouse traps also are efficient. Trapping is a suitable method of killing mice indoors when there are only a few and their runways are known.

2. BAITING.

a. Formula A (For Mice in and Around Buildings).

Canary seed (Phalaris)*	10 lb
Starch (gloss laundry)	⅓ oz
Karo syrup (blue label)	2⅓ fl oz
Water	6⅓ fl oz
Strychnine alkaloid	1.0 oz

* Oat groats, whole wheat, or milo maize may be substituted.

Dissolve or suspend the poison in the water and syrup and bring the mixture to a boil. Make a paste of the starch in a little cold water and add it to the boiling mixture. Continue to cook until the mixture clears; then remove it from the heat and pour it over the seed or grain and mix thoroughly and quickly. Use bait boxes for exposure to mice.

b. Formula B (For Mice in and Around Buildings).

Oatmeal or dry bread or cake crumbs	8 lb
Syrup or bacon fat	
Strychnine alkaloid (powdered)	1 oz

Moisten the cereal lightly with either syrup or melted fat, adding only enough so that the powdered poison will adhere. Mix the poison with a little flour to increase the bulk, and sift it into the bait while stirring the latter. Mix well and expose in bait boxes. (Avoid breathing the powdered poison.)

c. Formula C (For Mice in the Field).

	Large batch	*Small batch*
Oats (steam-rolled)	100 lb	10 lb
Corn oil (salad oil)	25 fl oz	2½ fl oz
Zinc phosphide	1 lb	1⅙ oz

Add powdered zinc phosphide to the oil and beat until evenly suspended. Pour over grain and stir until thoroughly mixed.

d. Formula D (For Mice in the Field).

	Large batch	*Small batch*
Fresh apples, diced ½ inch	28 qt	1 qt
Zinc phosphide	1 oz	1/28 oz

If the zinc phosphide powder is increased in bulk by adding at least twice its volume of flour or one-half its weight of magnesium carbonate, it will cover the diced apples more evenly.

e. Exposing Bait. Mouse bait should be exposed in buildings in boxes located along or near runways. Poison bait for field use should be scattered thinly in areas showing evidences of mice. This should be done so as to minimize the danger to beneficial birds. If unpoisoned food is abundant, bait with some other food commonly unavailable to the rodents.

3. ELIMINATION OF FOOD AND SHELTER. As in the case of rat control, conditions which provide food and shelter for mice should be eliminated wherever feasible. Field infestation may be reduced by removing refuse and by weed and brush control.

Section 3. OTHER PEST ANIMALS

C3.01 GROUND SQUIRRELS

1. GENERAL. Ground squirrels (*Citellus* species) are found in western North America from Alaska to Mexico, and from the Mississippi Valley to the Pacific Ocean. Similar species occur in Europe and Asia. The ground squirrels of western North America vary in length from 9 to 19 inches from nose to end of tail, and from gray to reddish brown with the brown color predominating. Some ground squirrels are called gophers but should not be confused with the pocket gopher. They live in burrows in the ground and usually are dormant during the winter. Many hole up soon after the breeding season in early summer. It is, therefore, important to carry on control operations in the early spring when all the squirrels are active. They are more common in open country than in heavy forest or brush growth, and feed upon seeds, especially grains, their activity being

limited to the daytime. They are also destructive of crops and forage, and their burrows cause damage to water reservoirs and airfields. Their control is important because they serve as reservoirs of plague and other diseases.

2. CONTROL WITH POISON BAITS.

a. Strychnine Formula.

Barley (clean whole grain)	16 qt
Strychnine alkaloid (powdered)	1 oz
Bicarbonate of soda (baking soda)	1 oz
Thin starch paste	¾ pt
Heavy corn syrup	¼ pt
Glycerin	1 tbs
Saccharin	1/10 oz

Mix the strychnine, baking soda, and saccharin together dry. Prepare the starch paste by stirring 1 heaping tablespoonful of dry gloss starch in a little cold water until smooth, pour into ¾ pint of hot water, boil and stir until clear. Add the dry mixture of strychnine, soda, and saccharin, then the corn syrup and glycerin; stir thoroughly. Pour the hot mixture over the grain, turning and stirring until each kernel is coated. Spread the coated grain out in a thin layer until the coating is thoroughly dried. Then store in a can or sack properly labeled *POISON*.

b. Zinc Phosphide Formula.

Oat groats (hull removed), lightly rolled	100 lb
Zinc phosphide, powdered	7 to 10 oz
Petrolatum (vaseline), melted	16 to 24 fl oz

Mixing is done best in a steel drum containing baffle plates and mounted at an angle. Turned by a crank, this device tumbles and mixes the materials thoroughly. The oats and poison should first be mixed dry until the kernels are evenly coated. Then the melted petrolatum is added and the drum turned again 30 to 50 revolutions. Mixing and handling the poison grain should be done outdoors. Personnel should wear gloves and should avoid breathing fumes from the poisoned material.

c. Choice of Formula. Strychnine bait is effective only when the squirrels are "pouching"—gathering seeds or grain in their cheek pouches to store or to carry to some favorite eating place. The strychnine is absorbed through the pouch lining. When the squirrels are feeding, they quickly remove the hull and are not affected by the strychnine coating. At such times, zinc phosphide bait should be used. Prebaiting part of the area with unpoisoned grain is a simple test to determine whether the squirrels will take the bait and whether it will be "pouched."

d. Application of Bait. The poisoned grain should be scattered by hand or with a spoon on hard bare ground, or along or near the cleared surface of runways, where it will be easily found. About 1 tablespoonful should be scattered at each spot for each 1 to 2 square feet covered. One quart of strychnine bait provides 30 to 35 baits. Baits should be placed inside the squirrel burrows wherever livestock otherwise may be endangered. County agricultural agents often can supply information as to the local conditions affecting ground squirrel control.

C3.02 PRAIRIE DOGS

1. GENERAL. Prairie dogs are smaller relatives of the woodchucks or ground hogs, and occur on the western plains of the United States. They usually live in open grasslands, but occasionally may be found in brushy areas, in colonies or "towns" where they construct extensive burrows. Their food consists chiefly of stems, roots, and seeds, and they often are destructive to agricultural crops. They are active only in daylight, and in colder areas become dormant in winter.

2. CONTROL BY BAITING. The commonly recommended method of controlling prairie dogs is by the use of poison bait. (The strychnine formula for ground squirrels will kill prairie dogs.)

C3.03 POCKET GOPHERS

1. GENERAL. Pocket gophers are so-called because of their large cheek pouches. They are found west of the Mississippi River and in parts of Wisconsin, Illinois, Indiana, Alabama, Georgia, and Florida. These animals are seldom seen outside their burrows, where they feed on roots, tubers, and bulbs. One pocket gopher may cover an acre or more with its tunnels and mounds, made by pushing earth aboveground at intervals through short lateral burrows. All openings are kept plugged with soil. The mounds cause hazards on airfield runways, and in training areas, and the burrowing of these animals may be destructive to planted areas on Navy installations and in areas where water is impounded. Sometimes underground cables are cut.

2. CONTROL.

a. Trapping. Trapping is effective if done properly. The Macabee gopher trap has proved the most satisfactory. In placing traps, select a freshly

constructed mound. Each mound is more or less fan-shaped, with the plug of the lateral burrow at the base of the fan. The main runway may be located with a probe or by digging out the lateral to its junction with the main tunnel. A trap should be set facing each way in the main runway because the gopher may approach from either direction.

In some cases, a trap is effective when set in the lateral if long enough so the trap does not extend into the main runway. The lightly plugged opening of the burrow is cleaned out with a long-handled spoon or a strong garden trowel, and enlarged sufficiently to admit the trap.

Traps in either a lateral or main burrow should be placed 12 to 18 inches inside and the burrow left open or partially closed. Air and light will bring the gopher to repair the tunnel. Baiting the traps is neither necessary nor advisable.

Fastening the traps to stakes with a light wire or cord is recommended. If the trap is not fastened, the captured gopher may escape with the trap, or another animal may carry away both gopher and trap.

b. Poisoning. Poisoning is usually the cheapest and quickest method of pocket gopher control, especially if a large area is involved. The main runway should be located with a probe and the bait placed in the runway. In most regions it is best to poison in the late summer and fall. As in all poisoning operations, the preparation and distribution of bait must have proper technical supervision. Bait is prepared from cut sections of sweet potatoes and carrots or from such grains as oats or wheat. Fresh clover and alfalfa leaves also have been used successfully.

Formula A

Sweet potatoes, carrots, or parsnips	2 qt
(*or* fresh clover or alfalfa)	1¼ lb
Strychnine alkaloid (powdered)	⅛ oz

Cut vegetables in pieces 1½ inches long and ⅜ inch square. Dust strychnine over baits and mix thoroughly. If clover or alfalfa is used, dampen lightly before dusting.

C3.04 MOLES

Moles occur chiefly in moist rich soils in which they feed on earthworms and soil insects. They have tiny eyes and ears, a pointed snout, and shovel-like front paws. They are larger than mice, and differ from pocket gophers which have a rounded nose and well-developed eyes and ears. In tunneling through the soil they make telltale ridges, especially in soft ground, disfiguring grass and ruining seedbeds and nurseries. Their runways may be used by mice and rats.

Moles occasionally venture out of their burrows at night. Ordinarily only one is found in a particular runway system, and since they usually repair damage to runways which are in use, it is easy to determine active runways for trapping by pressing down a small section of each ridge and observing which ones are repaired the next day. Several types of mole traps are available, of which the harpoon type is perhaps most satisfactory where runways are close to the ground surface. These traps require no baiting, but are set astraddle of the runway so that the mole passing beneath releases a trigger and is pierced by the harpoon.

C3.05 CONTROL OF COYOTES AND OTHER PREDATORS

Coyotes or prairie wolves find refuge on large reservations in the western states and travel from these relatively protected regions to prey upon domestic and game animals in nearby farming and grazing areas. Because they are reservoirs of rabies, control measures may be indicated. Control is usually by trapping. Technical assistance should be obtained in the application of control measures.

Section 4. CHEMICALS FOR PEST ANIMAL CONTROL

C4.01 GENERAL DESCRIPTION OF CHEMICALS

1. WARFARIN. Warfarin is a stable, grayish-white powder only slightly soluble in water. It is an anticoagulant compound which produces death by internal bleeding when consumed in small amounts over a period of several days. It is an effective poison for the control of Norway and roof rats as well as house mice. Mice appear somewhat more resistant and require a slightly longer time for satisfactory control. The poison concentration (0.025 percent) recommended for baits is so low that danger to domestic animals and humans is minimized. (Rodenticide, Warfarin, 0.5 percent; Spec. MIL-R-11261; QMC Stock No. 51-R-480.)

2. SODIUM FLUOROACETATE. (For proper safety precautions, see BuMed Instruction 6250.1.) Sodium fluoroacetate (1080) is a white powder,

readily soluble in cold water. It is nonirritating and can not be absorbed externally through intact skin. It is highly poisonous to all mammals, and is particularly dangerous to dogs and cats which contract secondary poisoning from feeding on dead or dying poisoned rodents. There is no effective antidote for sodium fluoroacetate, and it should be used with extreme caution. When used for rat control, the poisoned water formula is preferable to a solid bait containing this poison. Sodium fluoroacetate should be employed only where a qualified rodent control officer can directly supervise the operation. (Sodium Monofluoroacetate; Navy Stock No. G 51-S-3338-985, ½-oz can. All requisitions must be approved by BuMed.)

3. RED SQUILL. Red squill is the bulb of a plant which grows wild along the coast of the Mediterranean Sea. The bulbs are dried and powdered, and the powder is standardized by fortification with squill extractives to give a known toxic strength. The squill is distasteful to man and most animals and possesses a dangerous emetic action when consumed in quantities. Rats are unable to vomit, and so red squill is nearly specific for these animals. Active preparations of red squill are of particular value where the use of more dangerous rat poisons is inadvisable. Only properly fortified red squill should be employed. (Red Squill Powder, Navy Stock No. G 51-S-4840, 25-lb can.)

4. ZINC PHOSPHIDE. Zinc phosphide is a fine, grayish-black powder which is practically insoluble in water and organic solvents. It has a strong, characteristic odor of phosphorus, and is effective in the control of rats, mice, and certain field rodents. It has been displaced by sodium fluoroacetate for rat, ground squirrel, and prairie control. Zinc phosphide breaks down in the presence of moisture to release phosphine gas which is highly poisonous to man, and which is explosive when sufficiently concentrated. Workers with zinc phosphide should avoid breathing the fumes generated when the material is exposed to the air, and should refrain from smoking in closed rooms containing this substance. If exposure to the fumes results in headache, the patient should be removed to the open air. (Rodenticide, General Control, Zinc Phosphide, Spec. No. 4-115, Navy Stock No. G 51-Z-590.)

5. STRYCHNINE. Strychnine is available in two forms, the alkaloid and the sulfate. Both are usually extremely light powders, very bitter and poisonous. The alkaloid is almost entirely insoluble in water, but is dissolved readily in chloroform. The sulfate is somewhat water-soluble, but is almost insoluble in chloroform. Baits prepared with strychnine are of little value in rat control, but they are employed extensively against house mice and field rodents. Strychnine is rapid in its action. Its toxicity to man is high, and great care should be exercised in working with it. Avoid getting the poison in the mouth, and do not breathe the powder. First aid consists in obtaining prompt attendance of an experienced medical officer, in the meantime administering an emetic (if the patient has shown no symptoms of convulsion) and keeping the patient quiet and in darkness.

C4.02 PRECAUTIONS

Follow the same precautions for the use and storage of rodenticides as set forth for insecticides in Part B (B14.03).

BIBLIOGRAPHY

Manual of Naval Preventive Medicine. NAVMED-5010.

Insect and Rodent Control. Dept. of the Army TM 5–632, 156 pp., 1947.

Destructive and Useful Insects. C. L. Metcalf, W. P. Flint and R. L. Metcalf, 1071 pp., 1951. McGraw-Hill Book Co., N. Y.

The Use of Aircraft in the Control of Mosquitoes. Amer. Mosquito Control Assoc. Bull. No. 1, 46 pp., 1948.

Ground Equipment and Insecticides for Mosquito Control. Amer. Mosquito Control Assoc. Bull. No. 2, 116 pp., 1952.

Control Black Flies. U. S. Dept. Agri., Bu. Entomology and Plant Quarantine Circ. EC-20, 6 pp., 1952.

Methyl Bromide as a Delousing Agent. U. S. Dept. Agri. Circ. 745, 40 pp., 1946.

Chigger Control. U. S. Dept. Agri., Bu. Entomology and Plant Quarantine Leaflet 302, 7 pp., 1951.

Mites and Scrub Typhus. C. B. Philip and G. M. Kohls, Proc. Fourth Internat. Cong. on Trop. Med. and Malaria, Vol. 2, pp. 1656–63.

Residual Toxicity of Chemicals for Black Widow Spider Control. D. P. Furman and H. Kurtpinar, J. Econ. Entom., Vol. 43, pp. 343–347, 1950.

The Imported Fire Ant. U. S. Dept. Agri., Bu. Entomology and Plant Quarantine Circ. EC-17, 6 pp., 1951.

Preventing Damage to Buildings by Subterranean Termites and Their Control. U. S. Dept. Agri. Farmers' Bull. 1911, 38 pp., 1949.

Decay and Termite Damage in Houses. U. S. Dept. Agri. Farmers' Bull. 1993, 26 pp., 1951.

Termite Tent Toxicology. Cmdr. Conrad E. Grohs, CEC Bulletin, pp. 286–287 (Oct., 1950).

Control of Nonsubterranean Termites. U. S. Dept. Agri. Farmers' Bull. 2018, 16 pp., 1950.

Milky Disease for Control of Japanese Beetle Grubs. U. S. Dept. Agri., Bu. Entomology and Plant Quarantine Circ. EC-4, 8 pp., 1948.

Grasshopper Control with Aldrin, Chlordane, and Toxaphene. U. S. Dept. Agri., Bu. Entomology and Quarantine Pamphlet PA-149, 12 pp., 1951.

Insect Enemies of Eastern Forests. U. S. Dept. Agri. Misc. Publ. 657, 679 pp., 1950.

Rat Control. U. S. Dept. Interior Conservation Bull. 8, 27 pp., 1941.

Ratproofing Buildings and Premises. U. S. Dept. Interior Conservation Bull. 19, 26 pp., 1942.

Control of Destructive Mice. U. S. Dept. Interior Conservation Bull. 36, 37 pp., 1944.

Characteristics of Common Rodenticides. U. S. Dept. Interior, Fish and Wildlife Service Leaflet WL-337, 4 pp., 1952.

Mole Control. U. S. Dept. Interior Conservation Bull. 16, 17 pp., 1941.

Pocket Gopher Control. U. S. Dept. Interior Conservation Bull. 23, 20 pp., 1942.

Control of Rats and Mice. Tracy I. Storer, Calif. Agric. Extension Service Circ. 142, 37 pp., 1948.

Control of Field Rodents in California. Tracy I. Storer, Calif. Agric. Extension Service Circ. 138, 51 pp., 1947.

APPENDIX A

TABLES OF EQUIVALENTS

Lineal Measure (Length):

1 inch (in.) = 2.54 centimeters = 25.4 millimeters
1 foot (ft) = 12 inches = 30.5 centimeters = 0.3048 meter
1 yard (yd) = 3 feet = 0.9144 meter
1 rod (rd) = 5.5 yards = 16.5 feet = 5.029 meters
1 mile (mi) = 160 rods = 1,760 yards = 5,280 feet = 1.6094 kilometers
1 micron (μ) = 0.001 millimeter
1 millimeter = 0.0394 inch
1 centimeter = 10 millimeters = 0.3937 inch
1 meter = 100 centimeters = 3.28 feet = 39.37 inches
1 kilometer = 1,000 meters = 0.6214 mile

At maximum density at 39.164 F, one gallon of pure water weighs 8.345 pounds. At all temperatures up to 100 F, one gallon of water weighs approximately 8.3 pounds.

Square Measure (Area):

1 square foot = 144 square inches = 0.0929 square meter
1 square yard = 9 square feet = 0.8361 meter
1 square rod = 272.25 square feet = 30.25 square yards = 25.293 square meters
1 acre = 43,560 square feet = 4,840 square yards = 160 square rods = 0.4047 hectare
1 square mile = 640 acres = 259 hectares
1 square meter = 1,550 square inches
1 hectare = 2.471 acres = 10,000 square meters

Volume or Capacity Measure (Cubic):

1 cubic inch = 16.387 cubic centimeters
1 cubic foot = 1,728 cubic inches = 29.922 U. S. liquid quarts = 25.714 U. S. dry quarts = 0.80357 U. S. bushels = 28.316 liters
1 cubic yard = 27 cubic feet = 0.7646 cubic meter
1 cubic millimeter = 0.001 cubic centimeter
1 cubic centimeter = 0.001 cubic decimeter = 0.061 cubic inch
1 cubic decimeter = 0.001 cubic meter

Volume or Capacity Measure (Liquid):

1 level tablespoonful = 3 level teaspoonfuls
1 fluid ounce (U. S.) = 2 tablespoonfuls = 29.57 milliliters
1 cupful = 8 fluid ounces
1 pint (pt) = 2 cupfuls = 16 fluid ounces
1 quart (qt) (U. S.) = 2 pints = 0.9463 liter
1 gallon (gal) (U. S.) = 4 quarts = 0.8333 gallon (Imperial or British) = 231 cubic inches = 0.1337 cubic foot = 3.785 liters
1 gallon (Brit) = 1.2009 gallons (U. S.) = 4.546 liters
1 liter = 1,000 milliliters = 1.057 quart

Volume or Capacity Measure (Dry):

1 quart (U. S.)	= 2 pints = 1.1012 liters
1 bushel (bu) (U.S.)	= 32 quarts = 4 pecks = 1.244 cubic feet
1 bushel (Brit)	= 1.2843 cubic feet = 36.368 liters
1 liter	= 0.9081 dry quart (U. S.)

Weight:

1 grain (gr)	= 64.7989 milligrams
1 ounce (oz) (avoirdupois)	= 437.5 grains = 28.3495 grams
1 pound (lb) (avoirdupois)	= 16 ounces = 7,000 grains = 453.59 grams
1 ton (U. S. short)	= 2,000 pounds = 907.185 kilograms
1 ton (U. S. long)	= 2,240 pounds = 1,016.047 kilograms
1 microgram	= 1 gamma = 0.001 milligram (mg)
1 gram (gm)	= 1,000 milligrams = 15.432 grains
1 kilogram (kg)	= 1,000 grams = 2.205 pounds
1 ton (metric)	= 1,000 kilograms = 2,204 pounds

Temperature Conversion:

To convert degrees Centigrade to degrees Fahrenheit, multiply by $\frac{9}{5}$ and add 32. To convert degrees Fahrenheit to degrees Centigrade, subtract 32 and multiply by $\frac{5}{9}$.

°C	°F	°C	°F	°C	°F
−40	−40.0	0	32.0	40	104.0
−35	−31.0	+ 5	41.0	45	113.0
−30	−22.0	10	50.0	50	122.0
−25	−13.0	15	59.0	55	131.0
−20	− 4.0	20	68.0	60	140.0
−15	+ 5.0	25	77.0	80	176.0
−10	14.0	30	86.0	100	212.0
− 5	23.0	35	95.0		

In calculating intermediate values, 1° C = 1.80° F, and 1° F = 0.56° C.

SHORT METHODS OF CALCULATING DILUTIONS

The steps are as follows:

1. Make calculations first for one gallon, then multiply the results by any desired total number of gallons.

2. Divide the strength (percent) of the concentrate by the strength of the desired ready-to-use spray. This figure will be the total number of parts.

3. There being 128 ounces in a gallon, divide 128 by the number of parts obtained in step No. 2. This figure will be the number of fluid ounces of concentrate needed to make one gallon of spray. The remainder of the gallon will be diluent.

EXAMPLE NO. 1

Make one gallon (128 ounces) of 3% DDT solution from 30% DDT concentrate and base oil.

Total parts = 30 ÷ 3 = 10 parts
Ounces in one part = 128 ÷ 10 = 12.8 ounces

Therefore, the desired spray solution should contain:

Ounces of 30% DDT =	12.8	ounces
Ounces of base oil = 128 − 12.8 =	115.2	ounces
TOTAL	128.0	ounces

EXAMPLE NO. 2

Make one gallon (128 ounces) of ½% chlordane solution from 20% chlordane concentrate and base oil.

Total parts = 20 ÷ ½ = 40 parts
Ounces in one part = 128 ÷ 40 = 3.2 ounces

Therefore, the desired solution should contain:

Ounces of 20% chlordane	=	3.2 ounces
Ounces of base oil (by difference)	=	124.8 ounces
TOTAL		128.0 ounces

By making only slight changes in this method, it is possible to calculate the dilution of two different concentrates to make a desired spray mixture. Example No. 3 will illustrate.

EXAMPLE NO. 3

Make one gallon (128 ounces) of oil solution which will contain 5% DDT and 2% chlordane, using concentrates containing 30% DDT and 20% chlordane, respectively.

30% DDT Calculations

Total parts = 30 ÷ 5 = 6 parts
Ounces in each part = 128 ÷ 6 = 21.3 ounces of 30% DDT

20% Chlordane Calculations

Total parts = 20 ÷ 2 = 10 parts
Ounces in each part = 128 ÷ 10 = 12.8 ounces of 20% chlordane

Base Oil Calculations

It is evident that the quantity of base oil needed will be 128 ounces minus the total ounces of the two concentrates.

Total concentrates = 21.3 + 12.8 = 34.1 ounces
Base oil = 128 − 34.1 = 93.9 ounces of base oil

Therefore, the desired solution should contain:

30% DDT Concentrate	=	21.3 ounces
20% Chlordane Concentrate	=	12.8 ounces
Base oil	=	93.9 ounces
TOTAL		128.0 ounces

The short method also applies to calculations for making ready-to-use dusts from dust concentrates.

EXAMPLE NO. 4

Make 10 pounds of ready-to-use powder containing 5% chlordane and 10% DDT using 50% DDT dust, 50% chlordane dust and an inert powder, such as talc.

50% Chlordane Dust Calculations

Total parts = 50 ÷ 5 = 10 parts
Pounds in each part = 10 ÷ 10 = 1 lb 50% chlordane dust

50% DDT Dust Calculations

Total parts = 50 ÷ 10 = 5 parts
Pounds in each part = 10 ÷ 5 = 2 lb of 50% DDT dust

Inert Powder Calculations

Total of dust concentrates = 1 + 2 = 3 lb
Inert powder = 10 − 3 = 7 lb

Therefore, the desired dust should contain:

50% Chlordane dust	=	1 lb
50% DDT dust	=	2 lb
Inert powder	=	7 lb
TOTAL		10 lb

CALCULATION OF QUANTITY OF INSECTICIDE REQUIRED ON BASIS OF ACTIVE INGREDIENT

I. Water Suspensions or Solutions:

Example 1. Fifty gallons of spray containing 0.025% of rotenone is desired. The powdered root to be used contains 3.9% of rotenone. The quantity of this powder to be used is:

$$\frac{50 \times 8.345 \times 0.025}{3.9} = 2.7 \text{ lb}$$

8.345 = weight of 1 gal of water.

Example 2. One pound of ground derris root containing 4.8% of rotenone was used to make 50 gal of spray. The rotenone content of the spray was:

$$\frac{1 \times 4.8}{50 \times 8.345} = 0.0115\%$$

II. Dusts:

Example 1. 100 pounds of dust containing 0.50% rotenone is to be prepared. The powdered root to be used contains 4.0% of rotenone. The quantity of root required is:

$$\frac{0.50 \times 100}{4.0} = 12.5 \text{ lb}$$

Sufficient diluent is then added to make 100 pounds.

Example 2. Twenty pounds of ground cube root containing 4% of rotenone had been used in making up 100 pounds of dust. The rotenone content of the dust was:

$$\frac{20 \times 4.0}{100} = 0.8\%$$

III. Percentage of active ingredient when insecticide is diluted by parts:

Example 1. A spray containing 0.05% of nicotine is desired. The insecticide contains 40% nicotine.

$$\frac{40}{0.05} = 800$$

The dilution is therefore 1 part of the insecticide to 800 parts of water.

CAPACITY OF SPRAYER TANKS

The capacity of tanks of hand or power sprayers in gallons can be calculated as follows:

Cylindrical tanks (circular cross section): Multiply length in inches by square of diameter in inches, multiply the product by 0.0034.

Tanks with elliptical cross section: Multiply length in inches by short diameter in inches by long diameter in inches; multiply the product by 0.0034.

Rectangular tanks (square or oblong cross section): Multiply length by width by depth all in inches; multiply product by 0.004329.

DILUTION TABLE
FOR DIFFERENT QUANTITIES OF LIQUID SPRAY MATERIALS

Dilution	*1 Gallon*	*3 Gallons*	*5 Gallons*	*12 Gallons*	*50 Gallons*
1:125	1 oz or 2 tbs	3 oz or 6 tbs	5 oz or 10 tbs	12 oz or ¾ pt	3 pt
1:250	½ oz or 1 tbs	1½ oz or 3 tbs	2½ oz or 5 tbs	6 oz or 12 tbs	1½ pt
1:300	3 tsp	2½ tbs	2 oz or 4 tbs	5 oz or 10 tbs	1¼ pt
1:400	2 tsp	1 oz or 2 tbs	3½ tbs	4 oz or 8 tbs	1 pt
1:500	1¾ tsp	5 tsp	2½ tbs or 7½ tsp	3 oz or 6 tbs	¾ pt
1:600	1½ tsp	4 tsp	1 oz or 2 tbs	2½ oz or 5 tbs	11 oz or 21 tbs
1:800	1 tsp	½ oz or 1 tbs	¾ oz or 5 tsp	2 oz or 4 tbs	8 oz or ½ pt

APPENDIX B

PESTICIDES AND EQUIPMENT FOR APPLICATION

1. GENERAL. A successful insect and rodent control program is contingent upon the availability of the necessary insecticides, rodenticides, fumigants, and other chemicals, as well as the proper equipment for use. These pesticides are carefully screened and tested for toxicity, limitations of safe application, economy, and effectiveness prior to being accomplished in the interests of economy and adequate inspection of supply items. Local procurement of standard issue items will not be permitted except with approval of higher headquarters. The following items are grouped in accordance with the ease and economy with which they may be satisfactorily procured.

a. Navy Materials. The following items are from *Catalog of Navy Materials*, General Stores Section. The initial number indicates the class of the item and the section of the catalog listing the item. Superscripts indicate:

[1] These items will not be issued without prior approval of Bureau of Medicine and Surgery or Bureau of Yards and Docks.

[2] These items should not be used without prior reference to Section 14 of this publication and applicable BuMed series 6250 Instructions.

Stock No.	*Description of item*	*Unit of issue*
	Benzene hexachloride (specifications under preparation)	
G51-I-167-133 [1]	Lindane emulsion concentrate 20 percent	1-gal container
	CHLORDANE	
G51-I-155-355 [1]	Chlordane, water emulsible concentrate 46 percent	5-gal container
G51-I-155-375 [2]	Chlordane, 2 percent residual nonstaining oil base	1-gal container
G51-I-155-385 [2]	Chlordane, 2 percent residual nonstaining oil base	5-gal container
	DDT	
G51-G-120-31	DDT aerosol dispensers (indoor only) (Used cylinder G51-C-2031-10 will be forwarded in accordance with instructions in Class 51, General Stores Catalog)	1-lb cylinder
G51-G-120-44	DDT aerosol dispensers (indoor only) in case lots	44 lb
G51-I-156-55	DDT, 25 percent emulsion concentrate	5-gal container
G51-I-157-5 [2]	DDT, 100 percent powder technical concentrate	5-lb container
G51-I-157-25 [2]	DDT, 100 percent powder technical concentrate	25-lb container
G51-I-157-75	DDT, 75 percent water dispersible powder	15-lb container
G51-I-157-138	DDT, 20 percent insecticide DDT solution	52-gal drum
G51-I-157-600	DDT, 10 percent delousing powder in talc	5-lb container
G51-I-157-610	DDT, 10 percent delousing powder in talc	25-lb container
G51-I-165	DDT, 3 percent with 5 percent lethane, standard Navy insecticide	1-gal container
G51-I-171	DDT, 10 percent delousing in pyrophyllite or talc	2-oz can
	DIELDRIN	
G51-I-157-1625 [1]	Dieldrin, 18 percent emulsion concentrate	5-gal container

Stock No.	*Description of item*	*Unit of issue*
	MISCELLANEOUS INSECTICIDES	
G7-O-150	Oil, fuel diesel, grade 2-102	per gal
G51-D-190	Paradichlorobenzene	1 lb
G51-D-192	Paradichlorobenzene	100 lb
G51-D-237-400	Insect repellent, individual	2-oz bottle
G51-D-237-425	Insect repellent, clothing impregnation for scrub typhus	1-gal container
G51-M-888 [1]	Methyl bromide, clothing fumigant (use with 627-B-170)	20-cc ampules
G-27-B-170	Bag, fumigating, use with G51-M-888 for clothing fumigation	each
G51-M-889 [1]	Methyl bromide, for chamber and tarpaulin fumigation	1-lb container
G51-S-2333 [2]	Sodium arsenite solution (wood preservation, etc)	30-gal drum
	RODENTICIDES	
G51-C-418 [2]	Calcium cyanide, fumigant dust, (use with G41-D-4525)	5-lb container
G51-R-359-10	Warfarin, concentrate	1-lb can
G51-S-3338-985 [1]	Sodium monofluoroacetate, ½-oz can	1-lb box
G51-S-4840	Red squill	25-lb container
G51-Z-590	Zinc phosphide, 1-oz bottle	1-lb box
	EQUIPMENT	
G41-3-S-4120	Liquid sprayers, continuous spray, adjustable, for spraying DDT solutions and emulsions; 3-qt capacity	each
G42-F-8695	Fly swatters	each
G41-S-4112	Liquid sprayers, nonadjustable, Spec. N:41-S-44; 1-qt capacity	each
G41-S-4125	Liquid sprayers, air-pump type, with shoulder strap; 3-gal capacity	each
G41-D-4530	Powder dusters, crank-driven rotary blower type, for applying insecticide powders; 5- to 10-lb capacity	each
G41-D-4510	Powder dusters, plunger type, 1- to 2-lb capacity	each
G41-D-4525	Powder dusters, foot held, for applying calcium cyanide dust in rodent burrows; 5-lb capacity	each
37-G-1098	Rubber gloves, neoprene	pair
37-M-314	Respirator, gas fume, Type B-2	each
37-R-96	Cartridges, respirator, gas fume, Type B-2	each
40-S-2589-555	Sprayer, insecticide, gasoline engine-driven, without agitator	each
	Sprayer, insecticide, gasoline engine-driven, with agitator	each
G42-T-12525	Trap, mouse, 3-way snap	each
G42-T-12700	Trap, rat, cage type	each
G42-T-12900	Trap, rat, spring type	each
G42-T-12775	Trap, rat, V.G.	each
G-53-C-16803-125	Container, bait, rodenticide paper, to be used with rodenticide G51-S-3338-985	tube

b. Army Materials. Allowances of insect and rodent control supplies available are given in Department of Army TA 10-100-12 (7 October 1952) for items not listed in the *Catalog of Navy Materials.*

The following items may be obtained from Department of the Army Quartermaster by routing requests to (a) the Bureau having cognizance of the allotment, and (b) Bureau of Supplies and Accounts. Certain specialized items can be obtained from the Quartermaster more economically and with greater assurance as to standard content and safe application than to procure locally without specifications.

Stock No.	*Description of item*	*Unit of issue*
66-C-910	Chamber, fumigation, methyl bromide, nonportable	each
66-C-925	Chamber, fumigation, methyl bromide, portable	each
42-F-8650	Fly swatter pack; 500 per box	each
51-I-158-500	Insecticide, DDT and lindane, indoor fogging; for fogging operations inside warehouses to aid in controlling infestations	gallon
51-I-165-50 [1]	Insecticide, dieldrin 50 percent water, dispersible powder	pound
51-I-166-50	Insecticide, lime sulfur concentrate; for control of insects and fungi on trees, shrubs, and other plants	gallon
51-I-167-75 [1]	Insecticide, lindane 75 percent, water dispersible powder	pound
51-I-171-25 [2]	Insecticide, nicotine, sulfate solution 40 percent; for control of aphids, thrips, scale insects, and similar plant infesting insects	quart
51-I-188-75 [1]	Insecticide, powder, dusting, 1 percent lindane; for control of body, crab, and head lice, fleas, bedbugs; for use under supervision of medical officer only	pound
51-I-310 [1]	Insecticide, spray, delousing, 6 percent DDT, 68 percent benzyl benzoate, 12 percent benzocaine (ethyl paramino benzoate) and 14 percent nonionic emulsifiers. Stock solution must be diluted as follows, just prior to use: 1 part concentrate to 4 parts water. Kills adults and eggs of body, head, and crab lice. Also an effective scabicide. For use under supervision of medical officer only	gallon
51-I-187-75 [2]	Insecticide, standard lead arsenate, water dispersible powder; for control of insects on trees, shrubs, grass, and other vegetation	pound
51-I-190-75	Insecticide, sulfur, dusting; for control of mites, insects, and fungi on ornamental trees, shrubs, and other plants	pound
51-I-171-150	Insecticide, water emulsifiable oil, dormant spray; for control of scale insects, aphids, and other insects on dormant trees and shrubs	gallon
51-I-171-230	Insecticide, water emulsifiable oil, summer spray; for control of scale insects, aphids, and other insects on the foliage of trees and shrubs	gallon
51-M-910 [1]	Methyl bromide, 150-lb cylinder; for use in space fumigation	each

Stock No.	*Description of item*	*Unit of issue*
52-W-1084-55 [2]	Wood preservative, water repellent, ready mixed, 5 percent pentachlorophenol; for impregnation of lumber and other wood products for protection against wood-destroying insects and fungi	gallon

c. Local Procurement. Pesticides and equipment not listed in paragraphs a or b, Appendix B, may be purchased locally upon approval of higher headquarters in accordance with applicable Secretary of Navy 6250 instructions.

APPENDIX C

INSECT AND RODENT CONTROL FILMS

MA-220	"The Fly"
SN-1934A	"Field Sanitation—Series No. 1, Musca domestica"
SN-1934B	"Field Sanitation—Series No. 2, Culicidae Mosquitoes"
MA-1898	"Control of Louse-Borne Diseases"
MN-3726A	"Medicine in Action, No. 1 Pacific Enemy"
	"Medicine in Action, No. 2 Malaria"
MN-3726B	"Medicine in Action—Release No. 2, Typhus in Naples"
MN-3726C	"Medicine in Action—Release No. 3, Breakbone Fever (Dengue)"
MN-3726E	"Medicine in Action—Release No. 5, DDT"
MN-4176	"Malaria Discipline"
MG-4605	"Anopheles (census)—A Basic Field Procedure in Setting up Malaria Control Projects"
MA-5390	"DDT in Control of Household Insects"
MA-6861	"Control of Mosquito-Borne Diseases"
MN-4049	"Plague Control"
TF8-1669	"The Rat Problem"
TF8-1670	"Habits and Characteristics of the Rat" Part I
TF8-1671	"Habits and Characteristics of the Rat" Part II
TF8-1672	"Sanitation Techniques in Rat Control"
TF8-1674	"Practical Rat Control, Rat Killing"
TF8-1675	"Rat Ectoparasite Control"

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2. Locate the desired subject in Edge Index and place left thumb on the single- or double-line mark opposite that subject.
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